The
ENGINEERS' DIGEST

REVIEW OF WORLD ENGINEERING PROGRESS

VOL. XVII No. 2. FEBRUARY, 1956

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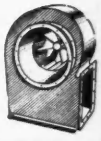

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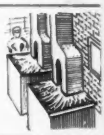

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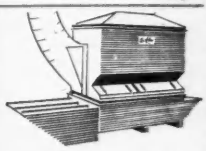

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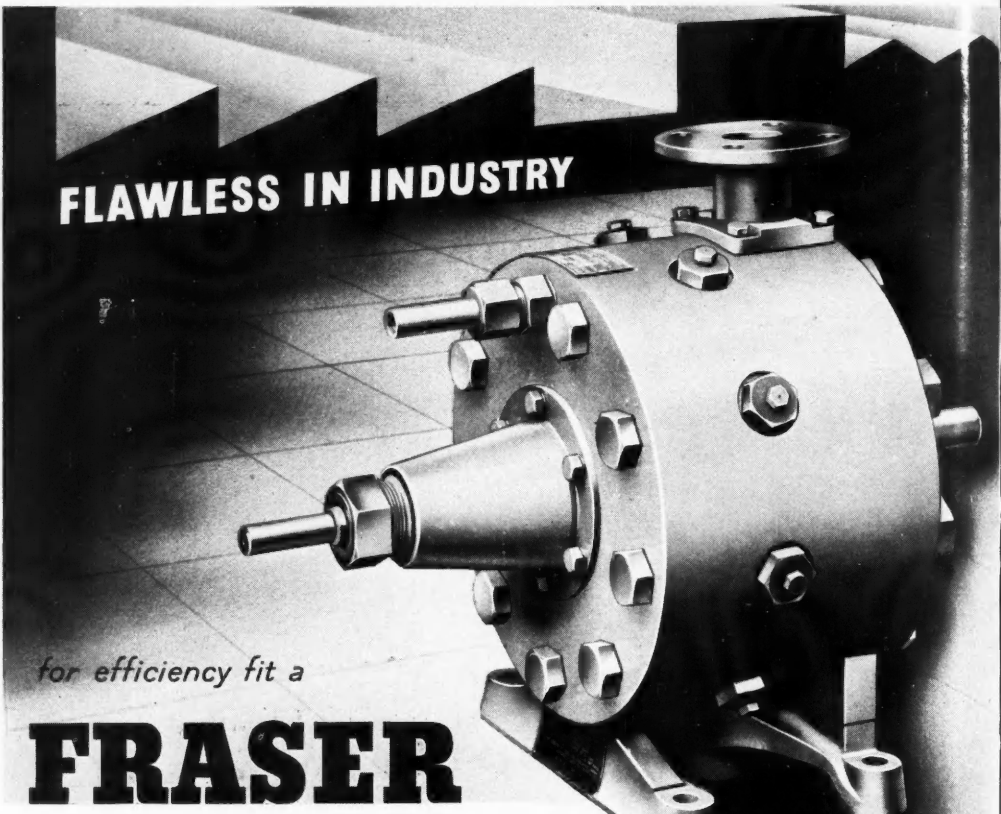

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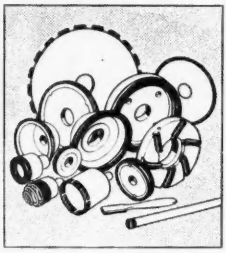

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THE BLUE PAGES

A QUICK GLANCE AT THE LATEST TECHNICAL DEVELOPMENTS THROUGHOUT THE WORLD

● *ADVANTAGES OF THE " LIQUID HONING " PROCESS*

The advantage of liquid-abrasive blasting or " liquid honing " lies in the fact that the process makes it possible to produce better surface finishes in less time than is feasible with any other surface-finishing process. Liquid honing can be used to remove tool marks and burrs from machined surfaces, to finish diecastings, to prepare surfaces for plating, to finish tools and dies, and also to remove scale, paint, and rust. In liquid honing, a mixture of abrasive material and water is ejected from a nozzle at high velocity. The nozzle is of special design, so that the mixture or " slurry " is accelerated by an air pressure of 80 to 100 psi to a high velocity as it leaves the tip of the nozzle. The abrasive may be aluminium oxide, silicon, or organic particles. The size of the abrasive grains and their concentration and velocity can be varied to give a number of surface finishes. Liquid honing can replace pickling, electrochemical cleaning, and hand-finishing of surfaces to be plated. It is stated that the most valuable use of this process in plating is in preparing surfaces of parts subject to hydrogen embrittlement. This is considered an especially important factor in plating aircraft components. By means of liquid honing the micro-inch finish of a surface can be considerably improved, especially in intricate sections impossible to clean by wire brushing. However, the finish obtained by liquid honing depends on the smoothness of the base metal. The process will not make a rough-ground piece as smooth as a finish-ground piece, but it will improve and chemically clean a good finish. It will do little to improve pitted or uneven surfaces, and in most cases it will magnify imperfections. On the other hand, this shortcoming of the process can be exploited for inspection of surfaces prior to plating, especially the surface of aluminium and magnesium castings, forgings, etc. Here, liquid honing will expose pits or porosities in those cases where machine grinding or polishing has caused metal to flow over these defective areas.

● *ELECTRICALLY CONDUCTIVE POLYVINYL RESINS*

It is known that rubber can be made electrically conductive by incorporating in it forms of carbon black which, owing to their crystal structure, tend to aggregate into chains and floes. Conductive rubber finds many applications in industry but, for certain purposes where increased chemical resistance is required, it would be desirable to substitute polyvinyl resins for rubber. It has, however, been found that, if the carbon black is incorporated in the polyvinyl resin by using the same technique as for rubber, the resulting compositions are unsatisfactory, owing to the great variations which occur in the conductivity of the products. It is stated that this difficulty persists even though various proportions of conductive carbon black or plasticizer are used. According to a recent patent, it has now been found possible to produce an electrically conductive polyvinyl resin which contains a dispersion of electrically conductive carbon black in rubber. The polyvinyl resin may be a polyvinyl ester such as polyvinyl chloride or polyvinyl acetate, or a copolymer of a vinyl ester with vinylidene chloride. For every 20 to 80 parts of polyvinyl resin, the proportion of the rubber used is preferably from 1 to 10 parts by weight, and the conductive carbon in the rubber is preferably from 5 to 30 parts by weight. Compositions containing little or no plasticizer can be readily extruded to form rod conductors of high strength and flexibility, while compositions with a higher plasticizer content can be used as electrically conductive sheeting.

● *MECHANISM OF BORON HARDENABILITY*

A recent study provides experimental proof to support a theory of the mechanism by which boron affects the hardenability of steel. This theory asumes that transformation particles nucleate at concentrations of lattice imperfections in the steel where the energy level is high, and that boron, because of its atomic diameter, also concentrates at the same points, lowering the energy level. Thus, boron would lower the energy level of potential nuclei and lessen the probability of nucleation. From this mechanism the nucleation rate would be expected to decrease as the boron content is increased, until all available lattice imperfections are occupied. According to the theory, the nucleation rate should be at a minimum at this point. Further increases of boron, however, might increase the nucleation rate because of

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the increase in strain energy which should result from the lack of suitable sites for boron atoms. It could be predicted from such a proposed mechanism that a critical boron content exists which would furnish the maximum hardenability effect in steel. A careful study of a number of experimental boron steels has led to the following conclusions regarding this theory :— A critical boron content which produces a maximum hardenability does actually exist and there is a relationship between this critical boron content and the austenite grain size. The variation in hardenability with grain size in boron steels is largely the result of increasing concentration of boron in the grain boundaries with decreasing grain-boundary area (increasing grain size). There is an austenitizing-temperature effect which is independent of grain size and which becomes increasingly larger with boron contents higher than critical. The optimum boron content does not appear to vary appreciably with variations in carbon content. Finally, hardenability appears to be reproducible in low-boron steels when their grain sizes are the same.

● *SHEET-METAL FORMING BY MEANS OF DETONATION WAVES*

A recent invention envisages the use of detonation waves for the production of sheet-metal pressings. The term detonation is used to signify very rapid combustion, in which the flame front moves at supersonic velocities in the unburnt gases. The velocity of flame propagation is far greater in a detonation than in an explosion. The latter is a combustion process in which the velocity of flame propagation does not exceed the velocity of sound in the unburnt gases. In the case of detonation, the flame is initiated by, and remains associated with, a shock front, i.e., a wave front of high kinetic energy. This kinetic energy is utilized in the invention for forming sheet metal by superimposing the metal sheet over a die and directing against the exposed surface of the sheet detonation waves produced by igniting a mixture of a fluid fuel and an oxidizing gas in an elongated container having an open end. The device actually used for producing the detonation waves consists of a barrel of 3 to 6 ft in length, with a 1-in. bore, at one end of which is fitted an ignition chamber provided with a spark plug. The mixture is prepared in a mixing chamber discharging into the ignition chamber. It is stated that, when a copper sheet of 0·005 in. thickness is placed on a bas-relief die and the energy of repeated pulses from the detonation apparatus is applied to the sheet, the latter assumes the contours of the surface. Similarly, a copper sheet placed over a cavity in a die is forced into the cavity by repeated pulses from the detonation apparatus to form a bowl. There is no doubt that this proposal offers most interesting possibilities, but it would appear that a considerable amount of development work will have to be carried out to make this process a practical proposition, especially in view of the amount of noise generated by such detonations.

● *COLD CHAMBER FOR TENSION TESTING*

A low-temperature chamber has been constructed which uses helium as a refrigerant and which makes it possible to attain temperatures as low as — 452°F for the purpose of conducting tension tests on metals which are to be used in extreme temperature ranges, such as those encountered with guided missiles and supersonic aircraft. In the design of apparatus of this kind it is important to know which metals should be used for the construction of storage tanks for low-temperature liquid fuels and coolants, if these ever prove applicable to guided missiles. Oxygen for human consumption during the operation of high-altitude aircraft is already being stored in liquid form in metal containers at temperatures of about — 300°F. Tests made in the new chamber should furnish important information on the behaviour of metals at low temperatures, since the testing temperature is within 7·6°F of absolute zero. When a metal is to be tested, a sample about 1 in. in length by $\frac{1}{4}$ in. in diameter is placed inside the special vacuum-insulated chamber. Liquid nitrogen is used for the initial cooling of the chamber from room temperature to — 320°F. At this point liquid helium is introduced to lower the temperature to — 452°F. Nitrogen is used in the room-temperature to — 320°F. range because it is considerably more economical and efficient than helium at these temperatures. When the chamber and test sample are stabilized at the desired temperature, a tension load applied to the sample is gradually increased until it is fractured. During the test the temperature of the metal specimen and also the stress-strain readings from the specimen are recorded electrically. Stresses up to 260,000 psi can be applied.

● *ELECTRICALLY VARIABLE GAS-DIELECTRIC CAPACITOR*

A novel controllable capacitor of the variable gas-dielectric type is claimed to exhibit a high ratio of capacitance change to total capacitance. It is stated that, although the dielectric constant of the capacitor is not appreciably greater than unity, the capacitance change is sufficient to provide frequency modulation and control of self-excited oscillators. The capacitor consists of a pair of plates with a glass envelope located between them. The glass envelope contains two electrodes and neon gas

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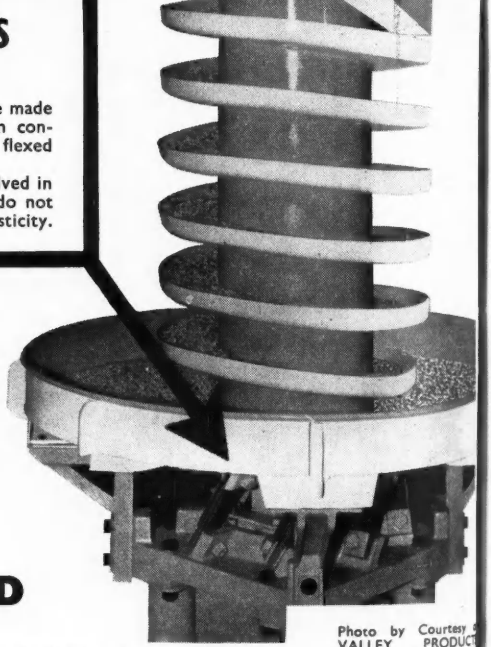

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of suitable density and ionizing characteristics, the neon occupying an appreciable part of the space between the two plates. Under the condition of no ionization, the aggregate dielectric constant will be slightly greater than unity owing to the glass envelope and the negligible amount of neon. That portion of the dielectric which is air and that portion which is glass will remain relatively constant, as will the insignificant amount of neon. When an ionizing potential is applied to the electrodes the part of the dielectric which consists of ionized neon will have acted to alter the aggregate dielectric constant. An increase in capacitance takes place when gas ions are generated between the two electrodes. The greatest capacitance change takes place between the conditions of no ionization and maximum ionization. There are quite a few cases where such abrupt capacitance changes can be utilized. It is, however, obvious that the use of the capacitor as a frequency modulator or similar proportional control requires the ionizing current to be maintained at some controllable level above the extinguishing point. The variable gas-dielectric capacitor can be considered to be a simple, efficient, and reliable device with applications in the frequency control of oscillators. It is potentially useful in other low-power circuits where small changes in capacitance are required to be controlled at rates to at least 20 kilocycles.

● *ADDITIVES FOR INSULATING OILS*

A patent of recent date describes an improved insulating oil especially applicable to oil-filled high-tension cables and for the impregnation of insulating papers of high-tension cables. It is claimed that saturated mineral oils, i.e., oils having a paraffin base, display the characteristic of liberating gases under the action of strong electric fields, so that gas occlusion occurs and ionization phenomena are likely to take place. This naturally is a disadvantage when using these oils in oil-filled cables or in transformers or for the impregnation of insulating papers. In contrast, oils having a large proportion of aromatic hydrocarbons or unsaturated hydrocarbons tend to absorb gas under the same conditions, so that there is no danger of cavities being formed within the dielectric. However, as these oils consist of an inseparable mixture of the most varied hydrocarbons, it is impossible to obtain uniform oils over a long period of time. For this reason it has been proposed to use oils of the paraffin series and to add approximately 2% of a hydrocarbon containing one or more double bonds or aromatic groups, such as naphthalene, which has the property of absorbing gas under the action of strong electric fields. Naphthalene has, however, the disadvantage of a high vapour pressure, and in vacuum treatment, such as the vacuum impregnation of cables, partial withdrawal of the naphthalene may therefore occur. The invention consequently envisages the addition of a hydrocarbon or hydrocarbon halide with a vapour pressure equal to or lower than the vapour pressure of the saturated mineral oil. A representative additive of this type is an oily mixed polymer of styrene and isobutylene. Styrene polymers with a low degree of polymerization, as for instance di- or tri-styrene, are also claimed to be suitable.

● *DESCALING STEEL HEATED TO FORGING TEMPERATURE*

During heating to forging temperature, steel ingots, blooms, slabs, and billets develop a so-called furnace scale composed of wüstite, magnetite, and in most cases a thin surface layer of hematite. If not removed, this scale tends to remain on the surface during forging, causing defects in the forged product. In a new descaling process use is made of the fact that furnace scale can be liquefied and thereby removed from steel at a considerably lower temperature than the fusing temperature of scale (ordinarily above 1400°C). In this process the furnace scale is contacted with lime or a lime-containing substance after the workpiece has been heated to a forging temperature above 1080°C, but less than 1400°C. At about 1080°C, the mixture of lime, magnetite, and wüstite starts to become fluid and at ordinary forging temperatures well below 1400°C, but slightly above 1080°C becomes very fluid and will either flow off or can easily be blown off the heated metal. A typical application of this process is in the removal of scale from billets for extrusion, such billets being customarily heated while suspended. The lime may easily be applied by blowing it through a port in the furnace as the billet approaches the exit end. In place of lime a number of lime-containing compounds such as calcium-ferrite and dicalcium ferrite may be used. The process is said to be equally applicable to all carbon and low-alloy steels, but it is not particularly effective for removing scale from steels containing large amounts of chromium and/or nickel.

● *PROGRESS IN VACUUM-METALLIZING APPLICATIONS*

The recent success of vacuum metallizing appears to be largely due to developments in the field of synthetic resins and lacquers for the base and the protection of metallized surfaces. In fact, vacuum metallizing is only as good as the protective film, and the excellent wear resistance of the new films may therefore be considered a decisive factor. There would appear to be many fields in which the vacuum-metallizing

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technique could be successfully employed. Thus, for instance, in the electroplating field, vacuum metallizing offers a rapid and inexpensive method of applying decorative finishes to hardware, plumbing fixtures, etc. It is even claimed that vacuum metallizing offers resistance to abrasion, salt spray, and humidity comparable with that of electroplated coatings. It must not, however, be overlooked that, while the metallized coatings are tough and durable, they can be gouged with a sharp edge and chipped by severe impact. In the vacuum metallizing of aluminium diecastings and of powdered metal parts, a difficulty arises in that the base coat of lacquer tends to be absorbed into the surface, with the result that it produces a rough finish. Several such coats are therefore required to produce a glossy base to which the metallized coating can be applied. Although the use of aluminium as a material for the metallized film is most common, other metals can easily be melted and evaporated. Aluminium is, however, the only metal which will conveniently wet a tungsten filament, and to evaporate copper, gold, silver, etc. a molybdenum trough or boat is used to contain the metal. Resistance heating is used to bring the boat to incandescence. Latest developments in vacuum equipment for metallizing include the use of more powerful pumps and larger chambers. With the latest type of equipment, a chamber of 6 ft diameter and 5 ft length can be evacuated to a vacuum of 0·5 micron in as little as 7 minutes.

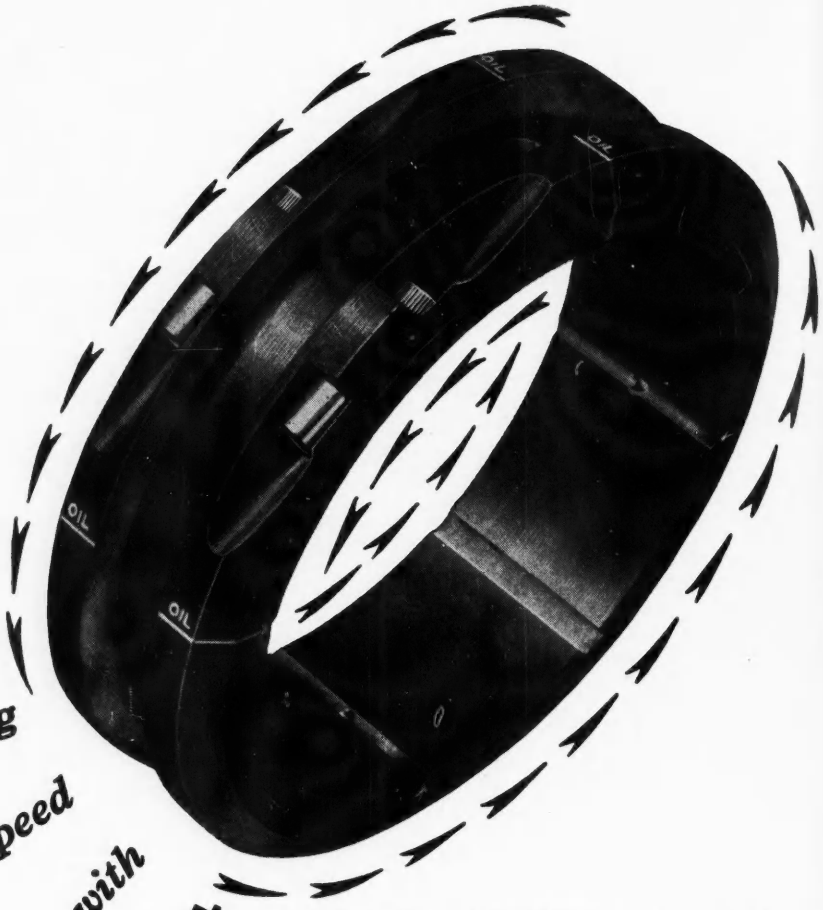
● *NEW TYPE OF A.C. VOLTMETER*

In electronic engineering an instrument which will accurately measure high a.c. voltage is frequently required. For this purpose an expanded-scale voltmeter has been developed which permits the indication of a narrow voltage range over the entire scale. This instrument is available both as a laboratory and a panel type. In the laboratory type a tapped input transformer permits the voltage range to be set conveniently, so that in actual use the applied voltage is equal to the sum of the readings of two taps plus the reading of the meter. In the panel-mounted instrument this adjustment is eliminated and the scale is expanded about the nominal voltage. It is claimed that accuracies of 0·25% over a frequency range of 50 to 2000 cps are achieved in the laboratory-type instrument, while accuracies of 0·5% over the same frequency range are obtainable with the panel-type instrument. Sensitivity can be made as high as 0·3 in. per volt. In both instruments a thermal bridge is used as the voltage standard. By utilizing the non-linear characteristic of a hot wire, a highly stable voltage standard has been made available. This element is used in a bridge circuit with wire-wound resistors, which, however, impose certain high-frequency limitations, while low-frequency limitations result from distortions caused by non-linearity during a cycle of the input frequency. The temperature coefficient of the bridge is very small because of the high temperature of the wire in the non-linear element, since a change in ambient temperature produces only a small percentage in the rise of the wire temperature. Moreover, this small coefficient is compensated by the provision of a temperature-sensitive resistor in one branch of the bridge. The high operating temperature of the non-linear element also produces a rapid response to voltage changes.

● *NEW TYPE OF DRY-CELL BATTERY*

A new type of dry-cell battery has been developed which is claimed to make possible a 30% increase in battery power and life. The new cell consists of a sandwich of artificial manganese dioxide mix between tiny discs of flat zinc and carbon electrodes. The old carbon rod of round-cell batteries has been supplanted by a small piece of conductive carbon, and the whole sandwich is machine-wrapped in an air-tight plastic envelope and heat-sealed. Welded or soldered wire connections between the cells are eliminated by the use of " silver wax ", a specially developed electrically conductive wax. A dab of silver wax on the negative and positive sides of the cell permits the cells to be connected in series merely by being stacked in a column, and a multiple-cell battery results from the electrical contact established between cells by the wax in pressure contact. Rigid inter-cell connections are maintained, even under rough handling, because the conductive wax yields and moulds itself to any necessary configuration required to maintain perfect electrical contact between the cells. Additional features are claimed to be the elimination of leakage between cells, and the ability to age and test each cell individually before it is incorporated into completed batteries. Moreover, a typical battery made up of these new cells contains almost one-third more electricity-producing mix than a conventional unit. The plastic cell envelope is only 0·0015 in. in thickness, enabling a maximum of the cell space to be occupied by energy-producing materials. Special machines have been built for the automatic production of these cells.

For further information on developments reviewed in THE BLUE PAGES, readers are invited to write to the Editor.



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Applications of Industrial Television in the Steel Industry

By J. MACALLA. (From *Iron and Steel Engineer, U.S.A.*, Vol. 32, No. 12, December 1955, pp. 66–71, 12 illustrations.)

TELEVISION is steadily gaining in popularity as a centralized control instrument in all types of steel-producing and associated industries, as the resulting remote visual supervision it affords permits a more efficient and exact control of the widespread, interdependent processes typical in steel manufacture. Furthermore, in addition to its value as a medium of interplant communication and as a means of instruction and training, industrial television is a valuable research tool, as cameras can be located in hazardous or physically uncomfortable positions.* A picture of conditions taken from such a vantage point will often permit a better appraisal of the effects of hitherto hidden locations.

In the U.S.A., industrial television was first applied in 1946 as a means of providing power engineers with a fail-safe check on water level. Then, in 1948, established as an industrial instrument, it was applied to a control problem in a continuous-casting pilot plant. In this process, the central control operator was required to keep a steady supply of liquid steel feeding to the forming chamber, and to know that the surface of the metal was free from foreign matter and that it carried a negative meniscus, a condition indicating proper mould temperature. The camera in this case was equipped with a long-focus lens and surrounded by an air-cooled housing to protect it from the intense heat. Mounted directly over the primary chamber, it provided the operator with a close-up view of the particular pouring operation in that area, permitting necessary adjustments to be made without the need for arm signals from a second observer, as previously required, with the consequent possibility of misinterpretation. Moreover, it eliminated a potential safety hazard.

At the moment, television finds its most popular application in the U.S.A. in hot strip fabrication, where it is used to assist slab reheating operations. In a typical example, a slab operator is located in a pulpit over slabs entering the central units (Fig. 1). Cameras, mounted outboard of the pulpit, provide him with a view of the slab-charging line, relative to the sides of the two flanking furnaces. Every movement of the slabs is plainly visible on two monitor screens, permitting rapid alignment to be made from this central position and, here again, eliminating the need for a second observer.

Another application of television in a strip mill concerns the control of hot strip run-out tables. As a slab progresses through the rolling process, disturbances created by uneven screw-down pressures may cause it to camber. This situation produces a hooked bar, which, when channelled into a coiler, results in a waste of time and material, or more often in uneven coils, which represent, in subsequent processing, a loss because of trimming. So that the mill operator can see the condition of the bar as it enters the coiler, a television camera is mounted in the roof trusses, directly above the coiler guides, transmitting a picture of the bar to the head rollers station. On a 10-in. monitor screen is projected a picture of the bar after it has passed beyond the water sprays, on its way to the coiler guide. If any camber is noted, the operator can make the necessary adjustments to his screw-down control, to correct for misalignment.

Industrial television has also been applied with great success to the control of moving material through automatic furnaces. In one example, steel tubes, 20 to 30 ft in length, are moved by a walking-beam conveyor, and supervision of this process is a desirable feature, as misalignment of these tubes might cause expensive damage to the refractory walls. Prior to the installation of industrial television, this operation required a man to be stationed near a viewing port—an impractical procedure because of the high temperature involved. Now, however, a television camera, protected by a water jacket and viewing through an air-cooled window, transmits a picture to a central control pulpit, where a single operator controlling the entire process line is located. Should any disturbance in the system be spotted, immediate corrective action can be taken. It should be noted that, in this particular installation, a second camera is employed to monitor the interior of an annealing oven located farther along in the same line. When this area must be observed, the operator,

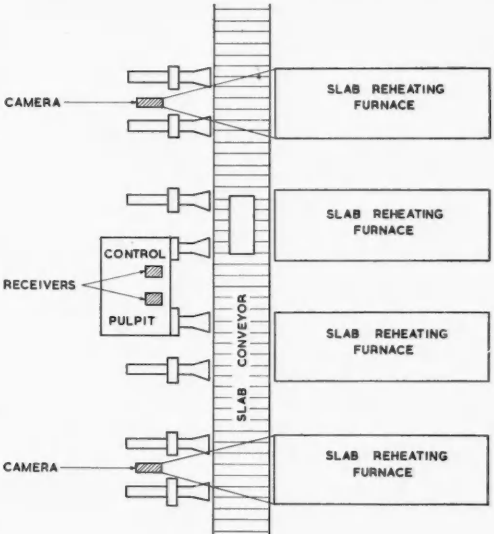

Fig. 1. Schematic diagram showing the use of industrial television in slab positioning.

* See *The Engineers' Digest*, May 1953, pp. 160–162. Ed. E.D.

by means of a selector switch, can see the tubes proceeding through the annealing furnace, all observations being made directly without dependence on assistants.

The extent of the acceptance of industrial television by the steel industry is shown by the duplication of many of the existing installations described above. Added to these are several new uses, the most interesting of which are two installations involving the observation of incandescent materials.

The first of these deals with the observation of the interior of a model open-hearth furnace. A television camera is so positioned as to provide a picture of flame conditions. Through the manipulation of various combustion controls, flame characteristics can be varied over a full range. These changes displayed on the monitor screen located at the control panel can instantly be observed, thus providing operators with a greater sense of assurance in their work.

The second new application deals with a control of skelp used in the manufacture of butt-welded pipe. Such a process demands that observation be established over skelp edge-heating as it emerges from a continuous furnace. Normally, the control operator positioned to view this point can clearly see only one edge. However, from the vantage point of a television camera located directly over this area, the operator can see on a monitor screen, a clear representation of the heating process on both edges. The picture, generated by a tube sensitive to infra-red radiations, shows the edges as bright bands contrasting sharply with the relatively cool centre body of the skelp.

Factors Influencing the Installation of Equipment

Industrial television in each of the above cases provides savings through the reduction of operation and/or capital equipment costs. In addition, it allows supervisors and operators a more exacting check on their responsibilities, without infringement of their safety. To evaluate these benefits properly, a survey should be made of the cost and problems involved in the installation and maintenance of equipment adapted to the rigours of steel-mill operation.

Industrial television in no way represents any great amount of complex equipment, and is based on four major points, i.e., simplicity, portability, low initial cost, and capability of sustained operation without frequent readjustment. Two popular types involve systems comprising two or three basic components. In one of these, the observation station is divided into two components—the camera pick-up head and its associated power supply. In the second type, all the observation and transmission functions are confined to a single unit. With both types, the camera output is usually transmitted to the receiver by a coaxial cable. The final selection of equipment will vary with individual applications.

Although the circuitry used in industrial television is greatly simplified and designed with adequate safety factors, the resulting picture is equal to, and in many cases excels, the resolution qualities exhibited by standard television receivers. Keeping the number of tubes to a minimum reduces the probability of equipment failure. To facilitate speedy repair, when necessary, all components are of standard values. These systems require only a minimum of adjustment under sustained operation. Units are capable of operating within temperature ranges of 0 to 125°F, in some cases to 150°F. To safeguard against varying line voltages, transformer-regulated power supplies assure operation, despite fluctuations between 80 and 135 V. Recent circuit developments also include an automatic electronic illumination control. This innovation allows the camera to adjust itself for changing scene-illumination values within a range of 8 to 1. Without such a circuit, changes in light values with this range can cause an interruption to the picture, unless manual compensation is introduced.

For industrial purposes, generally all signal information is transmitted on simple video frequencies, which are relatively immune to external electrical disturbances. The output of each camera is sufficient to power at least eight stations without any modification, a feature of benefit when the same picture must be transmitted to many locations. In other cases where one control centre must be used to view several different remote locations, any number of cameras can be switched into a single monitor.

From an economic standpoint, industrial television systems are within practical limitations. Moreover, provision for periodic or preventive maintenance should be included, when considering a system. This maintenance cost, allowing for replacement of the relatively expensive camera tube, should be about 25% per year of the cost of each set of equipment. The final cost of a system will naturally depend on the complexity of the individual application. Accessory equipment and, in particular, illumination requirements, will vary sufficiently to make their cost difficult to predict. However, in general, the total cost, even when based on a single year, will give a low cost per hour of operation.

To achieve the best results from an industrial television system, proper attention must be given to good engineering practice in initial installations. Steel-mill service usually entails three basic problems, i.e., heat, contaminated atmospheres, and illumination requirements. To provide for these conditions, an application must first start with the proper selection of camera pick-up tubes, of which two types are at present available, i.e., a photo-conductor tube and the image dissector. The dissector with the longest record of service is noteworthy from its cold-cathode construction. This feature guarantees it 8950 hours of operation with a potential life expectancy of approximately 15 years. In addition to a photo-surface most sensitive to the infra-red region of the spectrum, the electrical operation of the dissector is not particularly hampered by high temperature (200°F). Thus, it is particularly useful in applications involving the remote observations of flame or incandescent objects. The image dissector, however, is limited in its general application because of its low response to light and its resolution capabilities, both of which are interdependent. Normally, with respect to visible light, the dissector requires that 300 foot-candles be directed onto the area to be viewed. The impracticalities of this value, especially when large areas are in question, can easily be seen.

Permitting more practical illumination consideration is the photo-conductor tube, the newest of available camera tubes. Small (6 in. in length by 1 in. in diameter), this tube, although limited in life by an incandescent filament construction, may be considered to be good for over 5000 hours of operation, while optimum picture quality can be established with about 50 foot-candles of illumination. Usable pictures, particularly of scenes involving little motion may, however, be achieved with as little as 5 foot-candles of light. This tube is most sensitive to light in the blue-green portion of the spectrum. This, and the fact that it is a storage tube, permits it to be used successfully with mercury-vapour lighting.

The next consideration is the use of suitable accessories to ensure adequate protection of components, particularly against dirt and mill scale. Electronic equipment of any type is susceptible to disturbances generated by electrically conductive dust. In addition, the optics of the camera are hampered by dust of any type. Usually, the equipment manufacturer can supply special housings complete with filtered air supplies for maintaining a clear surrounding atmosphere to both the observation and reproducing components of a system. As a good practice, it is advisable to have this protection checked and supplemented, when necessary, by a regular programme of periodic maintenance.

The equipment requires protection from heat. In addition to possible carbonization resulting from prolonged exposure to high temperature, cameras employing photo-conductive tubes assume electrical characteristics which make them inoperative at temperatures in excess of 120°F. Heat may be dissipated successfully by the use of filtered air. When it becomes necessary to augment this arrangement, a simple enclosure, through which water may be circulated, can be constructed, so as to surround the sides and base-plate of the camera.

On many occasions specialized accessory equipment is required to allow the operation of equipment under extraordinary conditions. Specialized furnace-viewing accessories, such as the air-cooled window and the extended-image lens tube, are typical of these requirements. The air-cooled window consists of a chamber through which a stream of air passes against the high-temperature area. Camera viewing is achieved through a window located in the centre of the assembly. This window consists of a sheet of special glass, coated with a heat-reflecting surface, separated about 2 in. from a stainless-steel screen. This type of viewing has offered satisfactory service against contaminated areas involving temperatures of up to 2100°F.

The extended-image lens tube also finds great application in flame-observation work. Often, when viewing a furnace, it is desirable to see as much of the interior as possible, an operation often complicated by thick refractory walls. The lens tube, consisting of an optical system 36 in. in length by 3 in. in diameter, is designed to fit into an air- and water-cooled sheath. This entire assembly may then be inserted into an opening only 4 in. in diameter, yet permitting a camera to take in a 52-deg. viewing angle. By properly controlling the flow of water through the cooling chamber, the lens tube can be exposed to temperatures of approximately 2900°F.

Finally, after equipment and accessory selection has been completed, a last consideration should be observed in installing the system. Care should be taken to provide reasonable access to the various system components, thus facilitating periodic maintenance.

U. S. A.

Abrasive Rolls for Metal Finishing

By J. L. ERICKSON. (From *Prccision Metal Molding*, Vol. 13, No. 12, December 1955, pp. 61–62, 64, 6 illustrations.)

Although comparatively new tools for finishing metal parts, expendable rolls of coated abrasive cloth are finding, by virtue of their versatility, wide use in tool and die shops, as well as on finishing lines for the processing of precision metal castings.

AN abrasive roll is nothing more than a tool of an expendable nature used to abrade a softer material than itself for the purpose of cleaning, grinding, and/or polishing a surface. The abrasive roll consists of a continuous coil of coated abrasive strip wound and glued tightly together in the form of a roll.

In use, the roll is mounted on a mandrel, which slips into a central hole left for this purpose during the preparation of the roll. The mandrel is then revolved by a suitable power unit at a speed between 1000 and 35,000 rpm, and the revolving roll is pressed against the surface to be cut, or worn away, by the tiny particles of aluminium oxide (or silicon carbide) embedded in the surface of the coated abrasive cloth. When pressure is applied to the roll, the mandrel, which embodies a spiral taper, tends to screw itself into the inside diameter of the roll, thus preventing the latter from slipping. As the cutting action proceeds, the roll itself gradually wears away, as a result of the successive disintegration of the closely rolled layers of abrasive cloth, i.e., first the particles, then the cloth itself, then the next layer of particles, then the cloth, etc.

The following factors influence the degree of abrasion :

(1) The hardness of the abrasive particles embedded in the abrasive cloth used to make the rolls.
(2) The size, shape, distribution, and abundance of the abrasive particles.
(3) The degree to which the particles are bonded to the surface of the abrasive cloth.
(4) The force with which the particles are placed in contact with the surface to be abraded (a force which, in turn, is a function of the diameter of the roll, its rotational speed, and the magnitude of the force used to press the roll against the surface to be abraded).
(5) The nature of the surface to be abraded, i.e., its hardness, degree of smoothness, melting point, etc.

Unfortunately, however, it has not as yet been found possible to produce for shop use a mathematical formula which would enable estimates to be made of optimum

Fig. 1. Representative cartridge-type abrasive rolls.

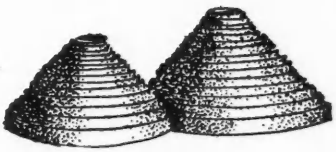

Fig. 2. Full-taper spiral types of abrasive roll.

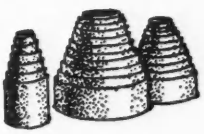

Fig. 3. Side-wall spiral types of abrasive roll.

grit size, roll shape, rotational speed, applied force, etc., given the physical and mechanical properties of the surface to be abraded and the end-results desired.

There are two major types of abrasive rolls, i.e., the cartridge type (sometimes referred to as the pencil type for small-diameter rolls), which has the same outside diameter over the whole length, and the spiral type, in which the rolls are tapered in diameter and which can be subdivided into two classes, i.e., the full-taper spiral and the side-wall spiral.

The smallest cartridge type of abrasive roll (Fig. 1) in common use is $\frac{1}{4}$-in. o.d. × $\frac{3}{4}$-in. face × $\frac{1}{8}$-in. hole size, while the largest is $1\frac{1}{2}$-in. o.d. × 2-in. face × $\frac{1}{4}$-in. hole size. Rolls both larger and smaller than these extremes are, however, made to order.

In the full-taper type of spiral roll (Fig. 2), which is normally supplied with base diameters ranging from $\frac{3}{8}$ to 1 in. and overall heights from 1 to $1\frac{1}{2}$ in., the outside diameter starts to decrease, beginning at the base end. In the side-wall type (Fig. 3), which provides side and angular abrasive surfaces, the outside diameter does not start to decrease up to one- to three-quarters of the distance between the ends of the roll, leaving the remaining length of the roll of uniform diameter. Side-wall types are usually supplied with base diameters ranging from $\frac{1}{2}$ to 1 in., overall heights from 1 to $2\frac{1}{2}$ in., and side-wall heights from $\frac{1}{4}$ to $2\frac{1}{4}$ in.

It is interesting to note that the thickness of the abrasive cloth used to make rolls varies with the size of the grit particles on its surface. The larger the grit particles (and the smaller the grit number) the thicker the abrasive cloth. It follows that, if it is desired to make a series of rolls of a given diameter, it takes a longer piece of abrasive cloth of large grit number to make such a roll than it does of a small grit number. In other words, more raw material (in this case, abrasive cloth) is used to make a given roll from a large grit number than from a smaller grit number (by length). Since the cost of the raw material is predicated on the cost of this material per foot, the cost of abrasive rolls of a given diameter is a function of the grit number.

Abrasive rolls are cheap to use. Their initial cost is very low compared, for example, with mounted stone points, and their final cost is also low, because they are not subject to the breakage characteristics of ceramic-type cutting wheels and of most mounted hard-stone points. Furthermore, even though they are expendable, they last a relatively long time.

Other advantages of abrasive rolls include the fact that they are safe in use, as they cannot break up into dangerous fragments, and that they are flexible and therefore tend to assume the shape of the surface with which they are in contact, thereby ensuring even cutting. In addition, they wear away evenly.

GERMANY

The "Dynamoscope" Mechanical Load-Measuring Instrument

By W. KOENNECKE. (From *Werkstatt und Betrieb*, Vol. 88, No. 11, November 1955, pp. 727–730, 9 illustrations.)

THE measurement of forces is a problem which appears constantly in many applications. The requirements for a universal load-measuring device may be stated as follows: (1) It should be capable of giving measurements on ordinary components under investigation, without special preparation or modification; (2) it should be capable of determining both high and low loads with equal accuracy; (3) it should be insensitive to external influences and so reliable as to require no subsequent recalibration, even when very frequently employed; and (4) it should be of a sufficiently small size to allow it to be incorporated in testing apparatus, weighing machines, etc.

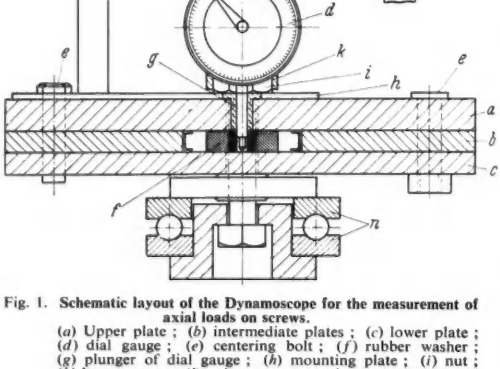

Fig. 1. **Schematic layout of the Dynamoscope for the measurement of axial loads on screws.**
(*a*) Upper plate; (*b*) intermediate plates; (*c*) lower plate; (*d*) dial gauge; (*e*) centering bolt; (*f*) rubber washer; (*g*) plunger of dial gauge; (*h*) mounting plate; (*i*) nut; (*k*) box-spanner; (*l*) pointer on upper plate; (*m*) protractor scale; (*n*) ball bearing.

In practically all load-measuring devices hitherto produced (mechanical, electrical, etc.), the accuracy attainable is related to the upper limiting value of load, so that good measuring accuracy is obtained only over a range of 1 to 10. Tensile testing machines, where precision is a primary requirement, have to be built as different models for capacities of 30 tons, 15 tons, etc., and, for still lower loads of about $\frac{1}{4}$ ton, an additional range of tensile machines is required. Special systems have been developed for measurements of axial loads on screws, but these require specially prepared specimens of suitable length and cannot take all types of screws. Moreover, weighing machines for high loads usually embody a spring-force mechanism, and their accuracy is about $\pm 2\%$ of their maximum load. They generally have to be supplemented by a small-size balance for loads below 10% of the maximum.

THE "DYNAMOSCOPE"

Basically, the "Dynamoscope" (Fig. 1) is a purely mechanical load-measuring instrument. The spring force is provided by rectangular plates, the upper plate, which is loosely positioned by centering bolts, being normally much thicker than the lower plate. The latter is flexible, and the loading is transmitted to it from the upper plate through intermediate plates, screwed to the upper plate. The arrangement is centrally loaded, and the relative distance between the plates, which, owing to the type of deflection, come closer to one another under

load, is measured by a precision dial gauge. The plates are made from high-quality tempered spring steel, with ground and lapped surfaces.

In the ordinary way, an arrangement of this type would have a measuring range of 1 to 10, but the essentially new feature of the Dynamoscope is that the supporting positions on the contact surfaces vary with the amount of loading. Under low loads, the bottom plate touches the intermediate plates at its outer edges, so that the distance between supports is, say, 220 mm. With increased loads, the lines (or very narrow surfaces) of contact are displaced towards the centre, so that the distance is reduced to, say, 50 mm. As deflection is proportional to the cube of the distance between supports, the result is that the midpoint deflection, relative to the load, can be reduced with a ratio of 85:1. Thus, additional accuracy is obtained by means of the varying spring stiffness of the system, as the device can be made in various sizes and with various plate flexibilities. By interposing a very soft elastic element, e.g., a rubber washer, in a central recess between the intermediate plates, it is even possible to obtain a condition where the plates will move away from one another, enabling small loads, down to 22 kg, to be measured with the desired accuracy.

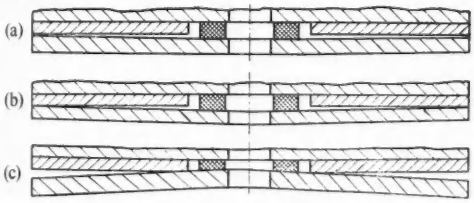

Fig. 2. **Movement of the plates of the Dynamoscope under (a) very low load, (b) medium load, and (c) high load.**

Details of the basic movements are shown in Fig. 2. With no load (Fig. 2a) there is no contact between the outer plates, owing to the rubber washer. Under a medium pressure (Fig. 2b) the rubber ring is compressed and the lower plate touches the intermediate plates at its outer edges. The maximum distance between supports then enables low loads to be measured with great accuracy. At high pressures (Fig. 2c), the lower plate passes through a condition of complete contact to the condition where it is supported at its inner edges, thus providing minimum bending distance.

Calibration tests show that the transitions are extremely gradual from one loading condition to the next. On the dial gauge, the range from zero to 40 kg is indicated by 120 divisions (1000 divisions = 1 mm total plunger travel) with a slight deviation from linearity. The next overlapping range, from 20 to 400 kg, is strictly linear, although the change occurs from the condition in Fig. 2b to that in Fig. 2c. From 400 to 4000 kg, the contact is at the inner edges, with linear relation between load and deflection, and the outer edges of the lower plate move about 2 mm away from the intermediate plates. The centering bolts are designed so that they cannot cause any binding which might affect the indication.

The basic requirements for absolutely reproducible results are perfect contact conditions for the plate surfaces and plunger, and rigid mounting of the dial gauge on the upper plate.

The apparatus is simple and sturdy and gives highly accurate measurements. Care should be taken that the load is centrally applied ; radial forces (not exceeding 100 kg) should be exerted only at the outer surface of the upper plate. The plunger of the dial gauge should not be bent or forced out of its normal position, since a distortion of even 0·02 mm. causes a corresponding error in indication. Because the Dynamoscope uses similar materials for all important components, it is not affected by different expansion coefficients and is insensitive to temperature in the range between zero and 50°C. Outside this range correction factors can be applied.

APPLICATIONS OF THE DYNAMOSCOPE

(1) Static spring characteristics can be measured with the arrangement shown in Fig. 3. The spring is mounted on a centering plate with a thrust ring on the upper plate and loaded by means of a press, or even a simple vice type of arrangement. A centering bolt, thrust ring, and plate are also required under the lower plate.

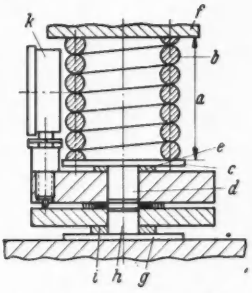

Fig. 3. **Arrangement used for determining spring characteristics.** (*a*) Total height of spring under load being measured ; (*b*) spring under test ; (*c*) upper centering plate, with bolt (*d*); (*e*) upper thrust ring ; (*f*) ram; (*g*) lower centering plate, with bolt (*h*); (*i*) lower thrust ring ; (*k*) dial gauge.

The apparatus will then indicate the force required to compress the spring by any specified amount. With suitable modifications, the load/deflection diagrams of leaf springs can also be determined. For measurements of dynamic loads, with the entire system subjected to oscillations, the relative deflection of the plates can be measured by an arrangement with strain gauges and electronic indicating equipment.

(2) A weighing system for static loads is shown in Fig. 4. The Dynamoscope is mounted on a base-plate resting on a solid frame, and the hook of the loading tackle is situated under the base-plate and carried by a

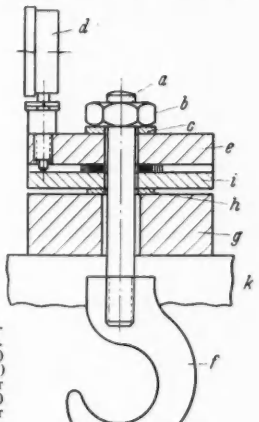

Fig. 4. **Arrangement of the Dynamoscope for weighing.** (*a*) Bolt ; (*b*) nut ; (*c*) upper thrust ring ; (*d*) dial gauge ; (*e*) upper plate ; (*f*) hook ; (*g*) base-plate ; (*h*) lower thrust ring ; (*i*) lower plate ; (*k*) frame.

screw passing through the upper and lower plates of the apparatus. The upper end of the screw is held in position by means of a centering ring and nut on the upper plate.

(3) The axial loads of screws, riveted connections, and other assemblies are of considerable importance. The elements normally connected together have a certain elasticity, which depends on the length and diameter of the components. Generally, for screwed connections, the " give " is of the order of 0·2 mm, a value which is also comparable with the initial elastic deflection of the Dynamoscope after reaching its minimum preload. The following screw-testing arrangements are of interest :—

(a) The normal case is where an axial load is to be measured on a screwed assembly subjected to a certain torque. As indicated in Fig. 5, a torque-wrench may be used for this purpose, the corresponding load being indicated by the Dynamoscope. Friction on the supporting surface can be taken into account by interposing a piece of material having the type of surface likely to occur in practice. The screw head, with a centering bolt and a nut of the same width as the screw head, is clamped in a vice. The nut should be fitted so that it will not touch the lower plate even at maximum load. A set of threaded adaptors for small-diameter screws is included in the accessory equipment. For screws of extra-large diameter, a larger size of Dynamoscope is required.

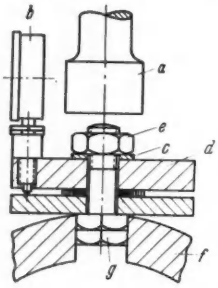

Fig. 5. **Measurement of axial loads on screws.** (*a*) Torque-wrench ; (*b*) dial gauge ; (*c*) upper thrust ring ; (*d*) upper plate ; (*e*) nut ; (*f*) vice ; (*g*) nut of centering bolt.

(b) For precision measurements of, for example, nut-locking devices, it is preferable to use a box-spanner, to which torque is applied via spring dynamometers, so as to obtain exact values of the loading torque. In addition to a vice and small Dynamometer, the test rig can include a protractor for indicating angles, when tightening or loosening the screw.

(c) In a further development of this rig, the friction of the nut on its support can be eliminated by interposing a ball bearing ((*n*) in Fig. 1). The screw head is held by a second box-spanner, which is clamped in a vice (not shown in Fig. 1). If the upper box-spanner with the spring dynamometers is turned through various angles, it is possible to determine the critical angle at which there is sufficient restoring action of the springs (i.e., sufficient torque) to overcome friction. The torque and load values thus obtained give an indication of the manufacturing accuracy of the profile and surface quality of the screw threads.

The static friction of the ball bearing can also be determined experimentally. This is achieved with the above rig, with two identical bearings mounted on top of one another. The load is applied through the Dynamoscope, but in other respects the rotation of the bearings is unimpeded. The frictional torque obtained with the spring dynamometers is for both bearings, so that the values indicated should be halved.

(d) By mounting a basically similar system on the table of a drilling machine, it is possible to determine the rolling friction of ball bearings. The lower bearing is then stationary and only the upper bearing rotates. An accurate investigation can be made in this way of the frictional losses due to ball-bearing inaccuracies, and of their coefficients of friction for various loads and speeds. Moreover, with cylindrical specimens of various materials in rubbing contact with each other, the coefficients of friction of steel on steel or other combinations of materials, with varying lubricating conditions, can also be measured satisfactorily.

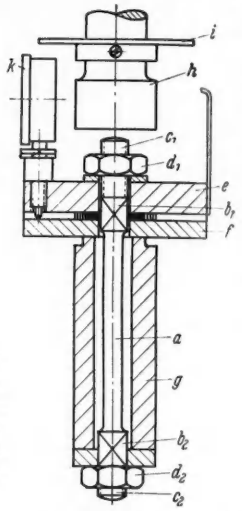

Fig. 6 **Dynamoscope rig used for strength investigations.** (*a*) Testpiece, with square sections (b_1) and (b_2) and threaded sections (c_1) and (c_2) ; (d_1), (d_2) nuts ; (*e*) upper plate ; (*f*) lower plate ; (*g*) sleeve ; (*h*) box-spanner ; (*i*) protractor scale ; (*k*) dial gauge.

(4) A further application of the Dynamoscope is in the determination of the rupture strength of materials. The requirement that no other forces except pure tension should be exerted on a testpiece is fulfilled very simply :— Tension is applied by a screw, the threaded section of which is formed by the upper part of the testpiece (Fig. 6). The square section passes through both the upper and lower plates, but only the upper plate is subjected to torsion. In order to obtain a simple assembly, the bottom end of the testpiece is threaded and held by a nut. The axial pressure on the lower thrust plate is transmitted to the lower plate of the Dynamoscope by means of a sleeve with an end-section of the same diameter as the normal thrust ring. The thread has a pitch of 1 or 2 mm, so that the variation in length can be obtained from the angle with an accuracy which is much higher than with conventional tensile-test machines. The angle is read on a protractor mounted on the box-spanner. As it is usually necessary to apply several turns, a revolution counter with a zero adjustment can also be incorporated in the testing system. The axial forces required for the elongation of the material are indicated on the dial gauge. The Dynamoscope is provided for this purpose with a square-section bore which does not restrict it in any way for other applications.

Finally, it should be noted that the measuring accuracy of the Dynamoscope can be kept to a constant value of $\pm 1\%$ over the entire range, up to the maximum value, i.e., a range of at least 1000 : 1, independent of ambient temperature, provided that no errors are made during calibration.

Transductors for Electrical Measurements

By L. Borg. (From *ASEA Journal*, Vol. 28, No. 7, 1955, pp. 110–116, 12 illustrations.)

Because of its current-transformer characteristics, the non-self-excited transductor is often used for current and voltage measurements. In this article, the design and connection of measuring transductors are described, together with indications of special measuring devices in which they can be employed and of the principle governing the use of the transductor as a measuring amplifier.

Transductors for Measurement of Current

A single-phase transductor consists of two similar single-phase transformer cores (the transductor elements) each having an a.c. and a d.c. winding. The arrangement used when measuring current (the series transductor) is shown in Fig. 1a, in which e_a is the a.c. supply voltage, i_a the a.c. current, and i_d the d.c. current. The two transductor elements are connected in series, with the one winding on the d.c. side reversed.

The direct current to be measured is assumed to be constant for one a.c. cycle—an assumption which corresponds satisfactorily enough with practical conditions. This is illustrated by the large smoothing reactor included in the d.c. circuit in Fig. 1a.

The actual excitation curve of the iron core corresponds, in principle, with that shown in Fig. 1b, in which magnetic flux Φ is plotted as a function of ampere-turns IN. For the sake of simplicity, this has been idealized in Fig. 1c, i.e., it rises vertically up to a certain flux (the saturation value), and then runs horizontally.

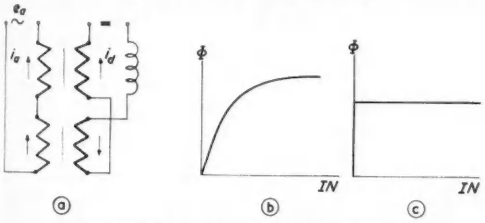

Fig. 1. Mode of operation of the series transductor.

The arrows in Fig. 1a show the direction of current flow in the windings at a given moment. As will be seen, the currents co-operate in the upper element and counteract each other in the lower element. In the element in which they co-operate, the core is saturated and, for that reason, the flux cannot vary. In the other element, where the currents counteract each other, the flux can vary if the magneto-motive forces of the currents are equal, so that the resulting magneto-motive force is zero, i.e., the core will operate on the vertical section of the excitation curve.

If the flux varies, the core can absorb alternating voltage in accordance with the law

$$e = N \frac{d\Phi}{dt}$$

The impressed alternating voltage must be absorbed somewhere, and this absorption can only take place in the unsaturated element where the currents counteract each other, and provided that the magneto-motive forces are equal. Therefore, the transductor will function so that this condition is fulfilled.

The oscillographic sequence shows that alternating current will vary abruptly between a positive and a negative value determined by the direct current and by the ratio between the turns. Thus, the rectified mean value of the alternating current is determined in accordance with the equation

$$I_a N_a = I_d N_d$$

where I_a is the rectified mean value of the a.c. current, I_d the d.c. current, N_a the number of turns in the a.c. winding, and N_d the number of turns in the d.c. winding.

As will be seen from the above, if the direct current varies, the alternating current will follow these d.c. variations.

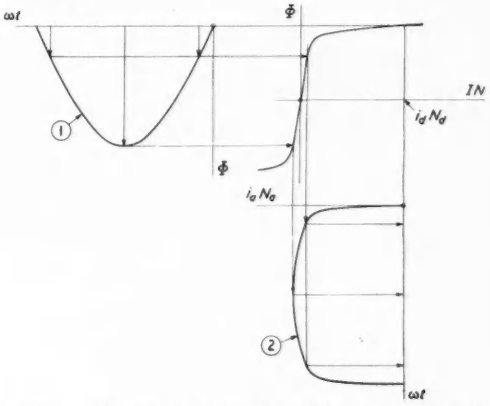

Fig. 2. Graphically construed wave-shape of alternating current in a series transductor.
(1) Wave-shape of the flux.
(2) Wave-shape of the alternating current.

For the purposes of this description, an idealized saturation curve has been assumed. In actual fact, the deviation from this is of minor significance. Fig. 2 shows how the appearance of the current is then derived. The change-over between positive and negative current values (the commutation) is no longer abrupt, but there is a certain inclination of the current curve, determined by the flux variation in the saturated region. At the top, the current wave is slightly curved because of the slope of the magnetizing curve within the unsaturated range.

The Nature of the Measuring Errors :—

It will immediately be seen from the account of the mode of operation given above how the errors arise in the measuring transductor.

Since commutation takes a certain time, some current is lost, reducing the mean value of the alternating current. On the other hand, the curvature of the horizontal part of the current curve causes a certain increase in the current, which, to some extent, compensates for the reduction in current in accordance with the above. This current addition depends on the size of the variations in flux and therefore depends on the supply voltage. In this way, with the magnetic materials normally used for this purpose, variations in supply voltage give a certain variable measuring error of the order of $\pm$ 1%.

This increase and decrease in the current results in a certain error (the basic error), which mainly implies a deviation in the ratio. When the direct current is zero, a certain current (the zero current) still flows, and this

causes a large error when measuring at less than 10% of the rated current.

Practical Design and Circuit Arrangement :—

The measuring transductor is normally used for measuring relatively high currents. It is then arranged as shown in Fig. 3. The direct current flows through the bar which goes through the cores and constitutes the d.c. winding. The a.c. windings are arranged on bobbins on the cores.

The current in the a.c. circuit is most simply measured directly by means of a.c. instruments. Since these are calibrated for measuring the r.m.s. value of sinusoidal current, special calibration is required, so that the instrument will show the mean value of the rectangular current. Therefore, this device is used mainly where there are many similar measuring devices.

In normal circumstances, it is more suitable to use a measuring rectifier, as shown in Fig. 3. This consists of a current transformer and a rectifier bridge combined in one housing. The current transformer is reconnectible for the different alternating-current values which may occur. In addition, there are tappings for the fine adjustment of the ratio. By means of these, the basic error can be compensated, so that the ratio of secondary current to the direct current is always correct.

Since the instrument current here is direct, a moving-coil instrument can be used, and this will show the mean value of the current, irrespective of the curve shape. Therefore, the instrument does not need to be calibrated specially, and standard instruments with standard dials can be used. Usually, the region adjacent to the zero mark is left ungraduated in order to obviate the possibility of incorrect measurement in that region.

Accuracy of Measurement :—

Variations in supply voltage cause a variation of $\pm$ 1% of the rated current. Other errors are compensated by adjusting the measuring rectifier. With reference to the error inherent in the instrument, there will be a total measuring error of $\pm$ 2% through the range from rated current to about 10% of rated current.

The influence of the supply voltage can be corrected by means of a special measuring rectifier with built-in compensating devices. The entire equipment, including the instruments, is then adjusted and tested in conjunction, giving a measuring error of $\pm$ 1% between rated current and 10% of rated current.

Load Capacity :—

It is often desirable to be able to connect relays, recording instruments, etc., which require a considerably greater amount of power than a mere dial instrument, into the measuring circuit. The possibilities of doing this are considerably greater when using measuring transductors than when measuring by means of a shunt. Depending on the size of the transductor, a pure resistive load of 25 to 350 W can be connected into the a.c. circuit with a mere 1% increase in the error. Under the same conditions, an inductive load of about 10 VA can be permitted for all sizes.

With extra loading of the d.c. circuits of the measuring rectifier, certain errors can arise because of the rectifier valve and the current transformer, but these errors can be completely compensated by adjusting the equipment in conjunction, and the same accuracy can be obtained as with the load in the a.c. circuit.

Remote Metering :—

When measuring direct current over moderate distances, it is advantageous to use measuring transductors with measuring rectifiers and to transmit the instrument current direct along a conductor. A measuring rectifier for 10 mA should then be chosen, so that the permissible length of conductor can be quite long before the voltage drop becomes too great. Measuring is then not affected by the normal variations in resistance in the transmission line, caused by variations in temperature.

With remote metering there is always the risk of the transmission line being interrupted accidentally during service, and such interruptions can also be deliberate, for example, on reconnection, if there are more measuring points than transmission leads. Because of this, interruption-proof measuring rectifiers, in which a glow-discharge lamp lights up and protects the rectifier valve against over-voltages, are available.

Measurement of Very High Currents :—

Currents higher than 10,000 A may sometimes be required, e.g., in the electrolysis of aluminium. A plant of this kind, however, obtains its current from several supply sets, e.g., mercury-arc rectifiers, so that each component set seldom gives more than 10,000 A. In such cases, it is usually most suitable to install a measuring transductor for each supply set. The measuring currents can then be summated by connecting the d.c. terminals in parallel on the measuring rectifiers. The total current thus obtained can then be measured in one instrument, while separate instruments are measuring the individual currents.

If an arrangement of this type is not suitable, a measuring transductor can be used for the total current, but it would necessarily have rather large dimensions. At such high currents, the simple series transductor is no longer suitable, since it then has a very large single-phase current consumption of rectangular shape, which a.c. supply networks will normally not tolerate. However, this difficulty can be avoided by using a form of differential connection. The principle of this is that the alternating current of the transductor is rectified and fed into an extra d.c. winding, the ampere-turns of which cancel out the greater part of the excitation field of the busbar. With a device of this type, a high current of practically unlimited magnitude can be measured with a total power consumption of only a few kVA.

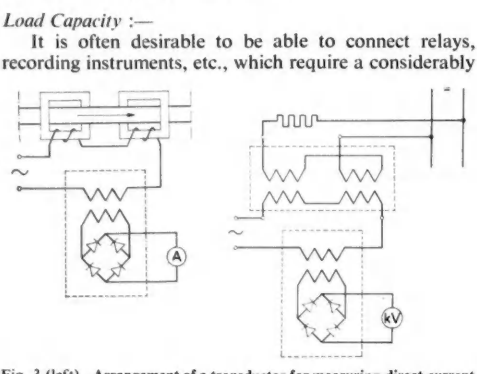

Fig. 3 (left). Arrangement of a transductor for measuring direct current in a busbar.

Fig. 4 (right). Arrangement of transductor for voltage measurement.

TRANSDUCTORS FOR MEASUREMENT OF VOLTAGE

Fig. 4 shows how a transductor is used for voltage measurements. A current which is proportional to the voltage is obtained by using a series resistor. This current is then measured by means of a series transductor, the

alternating current of which is converted in a measuring rectifier in the same way as when measuring current.

Standard types of transductors exist for this purpose. However, when they are used for very high voltages and with current sources having a low power output, the power consumption in the measuring circuit may assume excessive values. Measuring must then be carried out with a smaller direct current. However, it is hardly practical to make a simple measuring transductor for a few milliamperes.

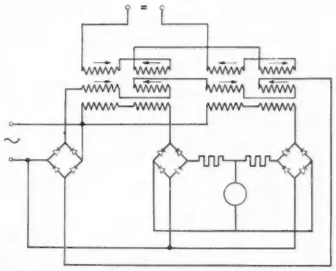

Fig. 5. **Differential connection for measuring small currents or for polarized measurement.**

Instead, two differentially-connected measuring transductors can be used for this purpose, as shown in principle in Fig. 5. The two transductors are pre-saturated by a common direct current, whereupon their alternating currents become equal. The difference between these two currents flows in the instrument circuit, and is then zero. The current in the measuring winding now increases the current from the one transductor and reduces the current from the other, so that a differential current, proportional to the metering current, flows in the instrument circuit. With the aid of this device, measuring currents down to the order of 1 mA can be used without difficulty, and this is sufficient in most cases. By using a special autoconnection a standard type of transductor can normally be used for this purpose. If an even lower measuring current is required, self-excited transductor amplifiers can be employed.

Advantages of Transductor Measurement

When direct current or direct voltage is to be measured, the choice is between transductor measurement and direct measurement with a shunt or series resistor. Transductor measurement is either advantageous or is the only possible solution in the following cases :—

(1) When a shunt will consume too much power or will be too costly, as is often the case at high currents.
(2) When the instrument circuit has to be insulated from the main circuit.
(3) When the instrument is to be placed at a considerable distance from the measuring point.
(4) When greater output is required than can normally be obtained with a shunt or series resistor.
(5) When several measuring values must be summated.

Special Devices

(*a*) *Improving Reproduction* :—

As will be seen from Fig. 2 and from the description of the mode of operation of the series transductor, a certain amount of current is lost during commutation. This appears on the rectified alternating current as a dip each half-cycle. Thus, oscillographic reproduction of the direct current will be impaired by these dips. Completely instantaneous reproduction is often required, for example if control or protective devices are to respond very rapidly to differences in the current.

One way of solving these problems is to use two measuring transductors connected to two alternating voltages with a phase displacement of such a nature (90 deg. is suitable) that one of the transductors is always in the region where instantaneous reproduction is obtained. Then, by means of a suitable valve connection, the numerically greater of the two currents can be sorted out, assuring instantaneous reproduction.

(*b*) *Minimum-Value Indication* :—

In many cases, a device is required which will indicate when the current or voltage in a circuit becomes less than a certain minimum value, which may often be very low. Directly connected relays are then exposed to a load which is perhaps 100 times the operating value, with consequent difficulties.

These difficulties can be avoided by using the arrangement shown in Fig. 6a. In normal service, the relay is then exposed to a voltage with a frequency of 100 cps, as shown in Fig. 6b, and this voltage does not change as long as the transductor is working normally. However, if the direct current becomes so low that the transductor no longer functions normally, the above-mentioned voltage is reduced and becomes zero when the direct current becomes zero. If the curve of this voltage is plotted as a function of direct current, it will be seen that it is favourable when the relay is to function at a low current value without being overloaded at full current.

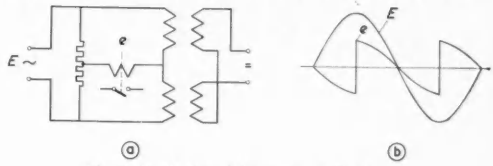

Fig. 6. **Device for minimum-value indication.**

The measuring transductor, which is of normal design, can be used simultaneously for current measurement.

Measuring Amplifiers

If the power value of the quantity to be measured is very small, the measuring devices described may not be quite suitable, because the power requirements of the measuring circuit may be too great and the induced voltages may be troublesome.

Self-excited transductors may then be used, since they require considerably less d.c. power for their control. With such devices, direct current can be measured with a power consumption down to the order of 10^{-9} W. However, at such a high rate of amplification, the transient response of the transductor is not particularly good, although this is not usually of importance.

Polarized Connections

If the quantity to be measured changes direction, the instrument current does not automatically follow suit. If the instrument is to indicate both the magnitude of the current and its direction, this can be arranged by displacing the operating point of the transductor by means of a special pre-saturation current, so that there is a certain current in the instrument circuit when the direct current in the busbar is zero. Current flowing in the

busbar in the one direction increases the instrument current and reduces it if it flows in the other direction. The instrument dial is marked zero at the rest position.

In many cases, it is not sufficient for the instrument to show the direction of current flow, since what is required is a current which, both in magnitude and direction, reproduces the current in the busbar. For this purpose too, use may be made of the arrangement shown in Fig. 5. Thus, the transductors are pre-saturated and their currents balance each other at zero current in the busbar. When the busbar is energized, the current from the one transductor increases, while that from the other decreases, so that a differential current flows in the instrument. If the currents in the busbar change their direction, the position is reversed and the instrument current changes direction.

RUSSIA

The Effects of Phosphorus in Magnesium-Treated Cast Iron

By K. I. Vaschenko and L. Sofroni. (From *Liteinoe Proizvodstvo*, No. 7, 1955, pp. 12–17, 14 illustrations.)

Normally, grey cast iron contains from 0·20 to 0·35% phosphorus. Within these limits, phosphorus raises the level of the rupture strength to a certain extent, but its harmful effect on the plastic properties of grey cast iron is not as pronounced as in steel.

In malleable cast iron, the phosphorus content should not exceed 0·18 to 0·20%. Despite their great practical importance, collective data on the effects of phosphorus on the change in mechanical properties of magnesium-treated cast irons have not been clearly established.

Effects of Phosphorus on Mechanical Properties

Melts were made in a 35-kg high-frequency furnace. The phosphorus was introduced into the cast iron in the form of ferrophosphorus (15·4% P), which was melted with the furnace charge, and its effect was studied with contents in the range between 0·08 and 0·9%. The cast iron was modified at 1420 to 1450°C by a mixture (15:85) of magnesium chips and 45% ferrosilicon, in amounts of 2% by weight of the metal (0·3% magnesium). The liquid cast iron was thoroughly mixed in a crucible before casting samples, from which testpieces were cut and heat-treated to give pearlitic and ferritic bases. For a ferritic base the treatment consisted of charging into the furnace at 650°C, heating to 920°C at a rate of 50 to 60°C/hr, holding for 4 hr at 920°C, cooling to 715°C at a rate of 90 to 100°C/hr, holding at 620°C for 1½ hr, and subsequently cooling in air. The treatment for a pearlitic base was to charge at 650°C, heat to 920°C at a rate of 50 to 60°C/hr, hold for 3 hr at 920°C, cool to 800°C at a rate of 100 to 110°C/hr, and subsequently cool in air. Obtaining the ferritic base required long holding in the region of pearlitic transformation, because of the drop in the rate of dissociation of the pearlite-cementite with increased phosphorus content. Final cooling in air was carried out from 600°C, as slow cooling from the furnace temperature would have led to brittleness in the cast iron.

The results of mechanical examination of the ferritic magnesium-treated cast iron with a phosphorus content show that, on raising the phosphorus content to 0·3%, the ultimate tensile strength increases slightly, but subsequently falls, the effect of phosphorus being only small. The elongation of magnesium-treated cast iron falls with an increase in phosphorus content (particularly between 0·18 and 0·25% P). Above 0·25% P, elongation falls less sharply. Phosphorus has a marked effect on the Charpy impact strength of ferritic cast iron, especially with phosphorus contents higher than 0·10%. Compressive strength diminishes with an increase in phosphorus content, particularly when the latter is above 0·25%, whereas Brinell hardness increases.

The results of mechanical examination of the pearlitic magnesium-treated cast iron show that phosphorus lowers the U.T.S. far more (by 35%) than with a ferritic base (by 8%). With an increase in phosphorus content, elongation drops. The Charpy impact strength suffers little change with increased phosphorus content, since, even with low phosphorus content, it is small. The compressive strength decreases with an increase in phosphorus content, but the Brinell hardness increases.

From these data, it has been established that the phosphorus content in ferritic magnesium-treated cast iron should not exceed 0·15%, and 0·20% in the pearlitic iron.

Phosphorus improves the wear resistance of magnesium-treated cast irons. Friction tests on specimens, with and without lubricants, have shown that pearlitic magnesium-treated cast iron with a phosphorus content between 0·4 and 0·6% has better anti-friction properties than a cast iron with a low phosphorus content.

Effects of Phosphorus on Structure

As is generally known, phosphorus has a very limited solubility in cast iron, and this solubility falls with a decrease in temperature and an increase in carbon content. With cast iron containing 3·5%C, the maximum solubility of phosphorus is 0·3%, whereas in pure iron it reaches 1·2%. In magnesium-treated cast iron with a phosphorus content of more than 0·15%, a phosphide eutectic forms, which increases in amount with an increase in phosphorus content. At first, the eutectic forms in isolated locations but, with a phosphorus content higher than 0·6%, it spreads in a network along the grain boundaries. The sharp decrease in the plastic properties and impact strength of magnesium-treated cast iron with a phosphorus content of 0·15 to 0·20% is connected with the formation of phosphide eutectic in the structure. Phosphorus also affects the structure of the metallic base. In the as-cast condition (prior to heat treatment), the amount of pearlite increases, and that of ferrite decreases, with an increase in phosphorus content.

In magnesium-treated cast iron, and also in grey cast iron, phosphorus retards the pearlitic transformation process, but in magnesium-treated cast iron this action is especially apparent.

Effects of Phosphorus on Cooling Curves

Cooling curves were recorded, using specimens of both grey and magnesium-treated cast iron, cast in both green and dry moulds. The effect of phosphorus content on the cooling curves of magnesium-treated cast iron, the compositions of which are given in Table I (samples *A*

TABLE I : PERCENTAGE COMPOSITION OF SAMPLES

Sample	Chemical Composition					
	C	Si	Mn	P	S	Mg
A	3·00	3·09	0·62	0·089	0·021	0·032
B	3·05	3·18	0·50	0·170	0·008	0·048
C	3·25	3·22	0·52	0·410	0·013	0·065
D	3·40	3·08	0·40	0·570	0·011	0·057
E	2·90	3·32	0·58	0·750	0·009	0·045
F	3·20	3·12	0·64	0·090	0·015	—
G	3·37	2·96	0·51	0·193	0·036	—
H	3·38	3·04	0·79	0·346	0·023	—
I	3·28	3·19	0·77	0·550	0·020	—
J	3·25	3·15	0·66	0·887	0·025	—
K	3·00	2·98	0·69	0·110	0·032	0·045
L	3·20	3·22	0·60	0·336	0·018	0·042
M	3·25	3·00	0·60	0·530	0·017	0·044
N	2·95	3·00	0·46	0·573	0·018	0·042
O	3·15	2·92	0·55	0·870	0·017	0·049

to *E* inclusive), cast in green moulds, is shown in Fig. 1, where it will be seen that, with an increase in phosphorus content, the eutectic stage on the cooling curve slopes more and takes less time. With 0·75% P, the horizontal portion of the eutectic stage disappears. On the cooling curves for the irons with relatively high phosphorus contents, the time of solidification of the phosphide eutectic in the bend of the curves at 930 to 950°C, i.e., a little below the melting point of phosphide eutectic (953°C), can be seen. The temperature of the eutectoid transformation changes very little with high phosphorus content. However, the higher the phosphorus content, the less clearly defined is the eutectoid stage, and with contents above 0·6% the eutectoid stage disappears almost completely. This is explained by an increase in the amount of phosphide eutectic in the structure and by a sharp drop in the amount of ferrite.

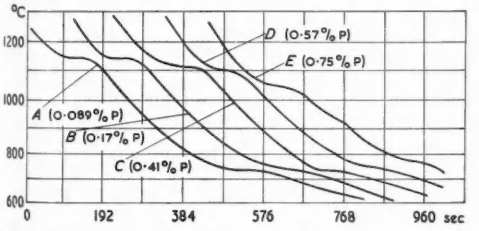

Fig. 1. **Cooling curves of magnesium-treated cast irons containing different percentages of phosphorus.**

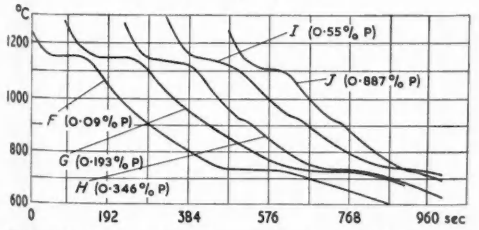

Fig. 2. **Cooling curves of ordinary grey cast irons containing different percentages of phosphorus.**

In order to obtain comparative data, an investigation was made into the effects of phosphorus on the cooling curves of ordinary grey cast iron, of the compositions given in Table I (samples *F* to *J* inclusive), on specimens cast in green moulds (Fig. 2). In contrast with magnesium-treated cast irons, on increasing the phosphorus content the eutectic stage in the cooling curves of ordinary grey cast iron appears as horizontal lines, the length of which, however, decreases with an increase in phosphorus content. The eutectoid stage is also less clearly marked.

With specimens of magnesium-treated cast iron cast in dry moulds, it was found that the temperature stages of the eutectic and eutectoid transformations and of solidification of the eutectic were less clearly marked than when casting in green moulds.

EFFECTS OF PHOSPHORUS ON CASTING PROPERTIES

The casting properties of magnesium-treated cast iron seem to be a combination of those of ordinary grey cast iron, of steel, and of white cast iron. Collective data on casting properties are not available, and the effects of phosphorus have not as yet been determined.

EFFECTS OF PHOSPHORUS ON FLUIDITY

Determination of the fluidity of grey and magnesium-treated cast irons was carried out by means of a method frequently employed, i.e., by casting a spiral of standard dimensions.

The effects of phosphorus on the fluidity of both grey and magnesium-treated cast irons were determined under identical conditions ($C + \frac{1}{4}(Si + P) = 4{\cdot}2$ to $4{\cdot}6\%$; casting temperature, 1250°C). It was found that, with an increase in phosphorus content, the fluidity of both types of iron increases, but more so in the case of the magnesium-treated cast iron. With low phosphorus contents, magnesium-treated cast iron also has greater fluidity, compared with ordinary grey cast iron.

The introduction of magnesium causes intensive desulphurization, degassing, deoxidation of the cast iron, and a lowering of non-metallic inclusions, with a favourable effect on fluidity. Maximum fluidity for magnesium-treated cast iron was obtained with a carbon equivalent of from 4·4 to 4·6%, and for ordinary grey cast iron with 4·2 to 4·3%, showing that the eutectic point in magnesium-treated cast iron moves to the right.

EFFECTS OF PHOSPHORUS ON LINEAR SHRINKAGE

Some data on the dependence of linear shrinkage of magnesium-treated cast iron on phosphorus content for a number of samples (*K* to *O* inclusive in Table I) are shown in Fig. 3. The microstructure of the magnesium-treated cast irons was ferritic-pearlitic, and the amount of free cementite was low.

As will be seen, on increasing the phosphorus content, the initial expansion prior to shrinkage increases rapidly. For cast irons of such composition, and with a uniform degree of graphitization, the maximum initial expansion

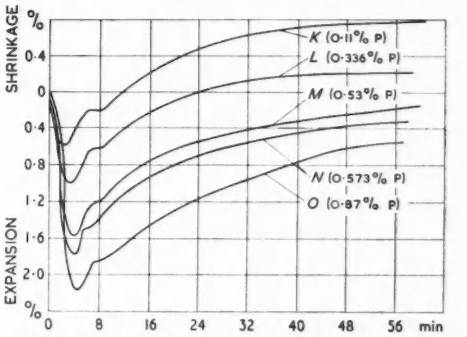

Fig. 3. **Linear shrinkage of magnesium-treated cast iron as a function of phosphorus content.**

is between 2·0 and 2·5%, corresponding to a phosphorus content of 0·70 to 0·87%. Above this content phosphorus has scarcely any effects on the initial expansion. With an increase in phosphorus content, the maximum of the initial expansion moves to the right ; expansion ends later. The temperature at the end of the initial expansion of magnesium-treated cast irons is noticeably lowered when phosphorus content is increased.

The end of the initial expansion prior to shrinkage is not found below 930 to 920°C, irrespective of the increase in phosphorus content. Shrinkage prior to the pearlite transformation diminishes a little when the phosphorus content is increased, but expansion during the pearlite transformation completely disappears. This is explained by an increase in the amount of pearlite in the structure with phosphorus contents higher than 0·60%, and the total absence of ferrite. The eutectoid transformation, in the case of a magnesium-treated cast iron with increased phosphorus content, can be seen on the shrinkage curve as a slope in the direction of increase in shrinkage, whereas, with low phosphorus contents, the curve of the pearlite transformation is in the direction of expansion prior to shrinkage.

To explain the reasons for the increase in expansion prior to shrinkage in magnesium-treated cast irons with increased phosphorus content, the effects of phosphorus on the linear shrinkage of grey iron, not modified by magnesium, were also studied. Shrinkage curves of two ordinary grey cast irons with different phosphorus contents are given in Fig. 4, the specimens being cast at between 1300 and 1340°C.

With increasing phosphorus content there is hardly any change in the initial expansion, but the shrinkage prior to the pearlite transformation drops slightly. Expansion at the eutectoid transformation of grey cast irons is far more independent of phosphorus content than in the case of magnesium-treated cast irons, and depends on the structure of the iron. The expansion at the eutectoid transformation attains maximum values with a ferritic base, and falls with an increase in the amount of pearlite and cementite. Variations in the phosphorus content of grey cast iron have hardly any effect on the expansion of cast iron at the eutectoid transformation. Thus, in ordinary grey cast iron, as opposed to magnesium-treated cast iron, an increase in phosphorus content scarcely increases initial expansion or decreases expansion at the eutectoid transformation.

To account for the marked expansion prior to shrinkage in the case of magnesium-treated cast irons, the linear shrinkage of a number of magnesium-treated white cast irons with different phosphorus contents was also determined. Two such shrinkage curves are included in Fig. 4.

It is of interest to note that, when determination was made of the linear shrinkage of magnesium-treated white cast irons (with high magnesium contents) of the same basic composition as magnesium-treated grey cast irons, no increase in expansion prior to shrinkage was found on increasing the phosphorus content. The expansion of magnesium-treated white cast irons prior to shrinkage is from 6 to 30 times lower than that of magnesium-treated grey cast irons, while expansion of the white cast irons prior to the pearlite transformation is just half that of the grey cast irons. Thus, the increase in the initial expansion in magnesium-treated grey cast iron with increasing phosphorus content is not connected with the nature of shrinkage of the phosphide eutectic.

A study of the structure of cast irons of different compositions, of cooling curves, and of shrinkage curves

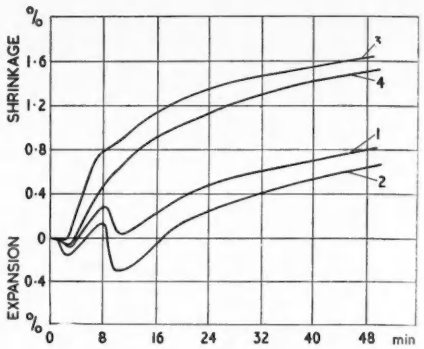

Fig. 4. Shrinkage curves of grey cast iron and of magnesium-treated white cast iron.

Curve (1) : Grey cast iron, with 0·06% P.
Curve (2) : Grey cast iron, with 0·55% P.
Curve (3) : Magnesium-treated white cast iron, with 0·40% P.
Curve (4) : Magnesium-treated white cast iron, with 0·70% P.

shows that the only factor responsible for great initial expansion of magnesium-treated grey cast irons is graphitization in the solid state. Phosphorus does not increase the degree of graphitization of either magnesium-treated or ordinary grey cast irons, but merely aids the expansion of magnesium-treated cast irons because of the weakness of the metallic base produced by the high proportion of liquid phosphide eutectic. Intensive graphitization in the solid state takes place in all cast irons containing moderate amounts of magnesium ; this is confirmed by the increased expansion of these cast irons, compared with grey cast irons not modified by magnesium. However, in magnesium-treated cast irons containing phosphorus, this process is seen more clearly. By raising the initial expansion and restricting the shrinkage prior to the pearlite transformation, phosphorus sharply reduces the linear shrinkage of magnesium-treated cast iron.

By casting specimens in dry moulds, it has been established that the initial expansion of magnesium-treated cast irons is reduced by 15 to 35% with a low phosphorus content (0·089% P), and by 30 to 40% with 0·710% P and above.

Other Effects of Phosphorus

An increase in phosphorus content also causes an increase in shrinkage porosity. Determination of the specific gravity of cast iron from a wedge section shows that, in the centre of the section with a phosphorus content of 0·73%, the specific gravity is 5·6; with 0·09% P, the specific gravity in the centre of the section is 6·0.

Owing to the high initial expansion of magnesium-treated cast irons with increased phosphorus content, the tendency towards the formation of hot cracks in thick-walled specimens arises. This is explained by the fact that, whilst the outer layer contracts, the inner layer expands. Since the strength of the outer layer is low, because of the presence of phosphide eutectic, hot cracks and deformation result when the interior expands. The higher the phosphorus content the further will the hot cracks spread in magnesium-treated cast iron.

An increase in phosphorus content considerably aids the growth of internal stresses. Grids of different core sections, usually employed to determine stresses, generally break in the mould during cooling, thereby preventing measurement of stresses by this method.

Fabrication of Zirconium by Powder-Metallurgy Techniques

By H. H. Hirsch. (From *Metal Progress*, Vol. 68, No. 6, December 1955, pp. 81-85, 160, 162, 5 illustrations.)

By means of powder-metallurgy techniques, solid zirconium bodies, possessing physical and mechanical properties approaching those obtained with arc-melted and worked metal, can be fabricated, while high-quality parts can be produced with practical temperatures, times, and pressures.

Although the first pieces of ductile zirconium were produced as early as 1914, it was not until after World War II that the American atomic-energy programme engendered a need for the quality and quantity production of ductile, high-purity zirconium and methods of consolidating and fabricating it into desired shapes. Two processes evolved, i.e., (1) the so-called Van Arkel process, which produces a crystal bar by the decomposition of zirconium tetraiodide on a heated filament, and (2) the Kroll process, which produces a zirconium sponge by reducing the tetrachloride with magnesium. The crystal-bar zirconium is somewhat purer, but much more costly.

Either product had to be worked into dense, usable shapes, and this proved to be as difficult a problem as producing the pure metal. No crucible could be found which would not react with molten zirconium. The current practice is to melt crystal-bar or sponge zirconium by inert arc into a water-cooled mould. The search for a more adaptable and possibly cheaper technique has led to the investigation of powder-metallurgy methods. Most of the effort has been directed towards cold-pressing and sintering, although some work has been done on warm-pressing and hot mechanical reduction, such as extrusion.

Preparation of Powder

There are several processes for producing zirconium or zirconium hydride powder, some of which were developed in the effort to make pure ductile metal. These processes include (1) hydrogen embrittlement of massive zirconium, (2) acid leaching of sponge, (3) fused-salt electrolysis of potassium zirconium fluoride, (4) reduction of zirconium with calcium or calcium hydride, (5) reduction of zirconium tetrachloride with calcium, and (6) reduction of sodium or potassium zirconium fluoride with sodium.

Of these six processes only the first three are now considered for producing high-quality powder. Powder of good quality can be obtained by the calcium or calcium hydride reduction of ZrO_2, but the high-purity calcium required is costly and the fine, lacy particles obtained have a very low bulk density.

In the hydride process, the ductile crystal-bar or sponge zirconium is embrittled by absorbing high-purity hydrogen. The hydride is then broken into powder, and ductility is subsequently restored by reversing the process —heat and high vacuum. Hydriding temperatures cover the range between 300°C for the sponge to 800°C for solid massive metal; dehydriding is at 800°C. Oxygen and nitrogen are increased during the process. Milling in an inert atmosphere can greatly reduce oxygen contamination.

Hydride powder can be used as such, but if it is to be converted into pure zirconium powder, it must be vacuum-fired and the resulting loosely caked mass broken up. This increases oxygen by 0·1%. On the other hand, acid-leached sponge is low in oxygen and nitrogen, but is rather rich in magnesium and chloride. These volatile materials may eventually be reduced by improved leaching techniques or by low-temperature prefiring of compacts before sintering.

Zirconium powder produced by fused-salt electrolysis appears to be about the best. Analysis for the small percentages of gases is at best a very difficult job, but it would appear that arc-melted ingots produced by this process compare very closely with arc-melted sponge produced by the Kroll process with about twice the oxygen content. Electrolytic zirconium powder can be readily handled in air, whereas dehydrided zirconium powder must be handled in an inert atmosphere.

Normal zirconium contains from 2·0 to 2·5% of hafnium, a high neutron-cross-section element. Reactor-grade zirconium must not contain any hafnium, and it can be separated by the chemical processes of ion interchange. However, most of the development work has been on zirconium powder containing hafnium, but the effect of the latter is small, owing to its very similar chemical nature to zirconium. The theoretical density of the 2·5% hafnium alloy is 6·52 gr/cm³, whereas that of hafnium-free zirconium is 6·49.

Cold-Pressing and Sintering

By far the greatest effort has been expended on this technique using zirconium hydride and dehydrided powders. The work was carried on in the U.S.A. by Hausner and co-workers and in England by Chuang.

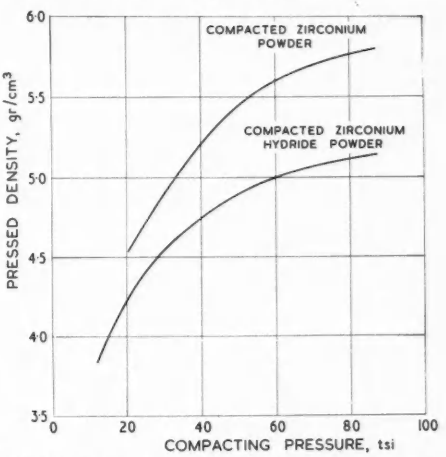

Fig. 1. Relation between pressed density of compacts and compacting pressure for zirconium metal powder and zirconium hydride powder.

Hausner prepared zirconium hydride from iodide zirconium, and also made zirconium powder from the hydride. As would be expected, the hard hydride did not compact to as high a green density as the straight zirconium compound. Fig. 1 shows the difference in density as determined on 2 × $\frac{3}{8}$-in. rectangular compacts. However, sintering in a high vacuum (of the order of 5 × 10^{-5} mm Hg or better) produced the reverse result. In Fig. 2, for example, the density as a function of compacting pressure is plotted for the two powders sintered at 1260 and 1320°C for 3 hr. The hydride compacts (containing 3% Hf) sintered to full density (6·59 gr/cm³) after 3 hr at 1260°C, when compacted at 65 tsi or higher. The metal-

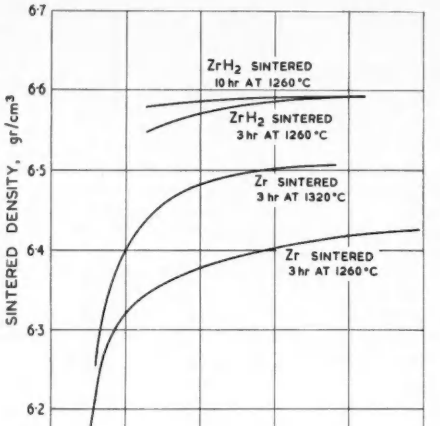

Fig. 2. Relation between sintered density and compacting pressure for zirconium hydride sintered for 3 hr and 10 hr respectively at 1260°C, and for zirconium sintered for 3 hr at 1260 and 1320°C respectively.

lic zirconium powder falls short of this mark even after a 3-hr period at 1320°C. The hydride compact decomposes during the heating cycle, and apparently the surfaces are extremely clean and reactive under these conditions. Theoretical density can actually be obtained by sintering a compact pressed at 50 tsi at the relatively low temperature of 1175°C for 9 hr. If copper and iron powders behaved in a similar fashion, they would sinter to full density at 660 and 975°C respectively, but, in actual fact, most pure metal powders never reach theoretical density as sintered. Zirconium is indeed unique in this respect.

Zirconium powder was pressed at 50 tsi on top of a lightly pressed ZrH_2 compress and sintered for 2 hr at 1190°C. Very little grain growth occurred in the Zr layer, whereas in the metal from the hydride it did—further evidence of its clean and reactive nature. Some porosity exists in the upper Zr layer, but intimate bonding occurred between the two.

Theoretical density can be achieved with zirconium hydride at pressures as low as 35 tsi, as shown in Fig. 3. Higher sintering temperatures and times, of course, are required. With pressures of 75 tsi, full density can be achieved at the very low temperature of 1050°C, if held at temperature for 7 hr.

Hausner determined that graphite boats and separators proved to be best for sintering, since zirconium reduced most of the common refractories with which it came into contact. He further established that 1260°C is the optimum maximum temperature; above this temperature the compacts absorb an excessive amount of oxygen. Also, compacts made from the hydride were more ductile and presumably more corrosion-resistant than those made from the decomposed hydride powder, primarily because of their lower gas content. The mechanical properties of the sintered hydride compare favourably with those of arc-melted products.

Chuang worked with two different types of powder, each of different quality from the above-described material used by Hausner. In one set of experiments, zirconium hydride was prepared from turnings made from graphite-melted ingots of sponge zirconium. It contained 0·16% C and relatively high nitrogen, which probably prevented high mechanical properties in the pressed and sintered compacts. Although the −200-mesh powder sintered to higher densities than the −100-mesh material, it had poorer strength, presumably because of a higher carbide content. Neither of Chuang's −100-mesh or −200-mesh powders reached the densities Hausner obtained with his very fine hydride, pressed and sintered under the same conditions.

The other powder used by Chuang was from acid-leached sponge. When compacted at 48 tsi, it sintered at 1050°C to a density of 6·2 gr/cm³; no further densification was noted up to 1300°C. Its mechanical properties show that this material is superior to the hydrided induction-melted sponge and nearly equivalent to hydrided iodide zirconium prepared by Hausner. No data are available on the relative corrosion resistance.

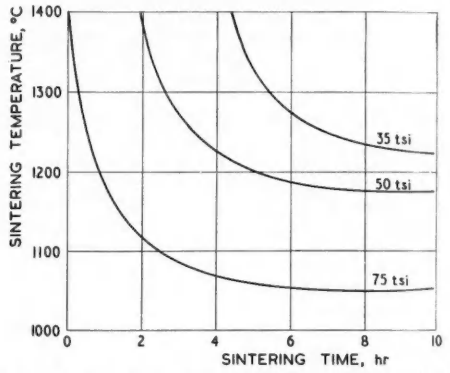

Fig. 3. Relation between sintering times and temperatures for achieving full density after compacting at 35, 50, and 75 tsi, with −325-mesh, vacuum-sintered zirconium hydride powder.

Small discs of zirconium powder produced by fused-salt electrolysis were pressed by the author at 50 tsi, and sintered at 1260°C in a high vacuum. The resulting density was 6·25 gr/cm³, and Rockwell hardness was B-88. This hardness value corroborates the low gas analysis of the original powder. The microstructure of this material appears dense, the grains are equiaxed, and probably slightly larger than in compacts of dehydrided zirconium powder sintered under the same conditions.

Extrusion and Pressing

Owing to the rapid increase in plasticity of zirconium with temperature, full-density bodies can be produced in temperature ranges where hardened steel dies can be used. Thus, Hausner warm-pressed zirconium powder (obtained from the decomposed hydride) at 650°C for 15 min *in vacuo* at 25 tsi. The compact had a density of 6·53 gr/cm³, but was slightly harder than the pressed and sintered bodies. This may have been due to contamination during the pressing operation or to the retention of volatile impurities which would be driven off during sintering at high temperature.

The author has warm-pressed electrolytic zirconium powder at 550°C for 15 min at 30 tsi. No attempt was made to exclude the air except through the close fit of the punches. Densities of 6·37 gr/cm³ were obtained, and the material had the low hardness of Rockwell B-75.

Beck has succeeded in hot-extruding cold compacts

(*Concluded on page* 68)

Method for the Combined Processing and Power Utilization of Solid Fuels

By Z. F. CHUKHANOV, L. N. KHITRIN, and V. A. GOLUBTZOV. (From *Teploenergetika*, No. 7, July 1955, pp. 3–12, 13 illustrations.)

In conventional power stations, many valuable byproducts, which could have been recovered if solid fuels were processed prior to their combustion, are unnecessarily wasted. This article describes the development of a method of combining in one plant the chemical processing of solid fuels with actual power production, using the flue gases from the boiler in the processing operation.

In conventional methods of utilization of natural solid fuels for the purpose of producing power, valuable liquids and such products as gas of high calorific value, which could be extracted by thermal processing of the fuel before combustion, are burnt. Thus, when burning 100 million tons of standard solid fuel in the boilers of power stations, 20 million m³ of gas of high calorific value and almost 5 million tons of liquid resins are uneconomically utilized.

Fuel utilization in industry is normally associated with a relatively low efficiency, between 20 and 70%. For instance, in producing gas of high calorific value in high-pressure gas producers, under a combined steam and oxygen blast, the gross calorific value of the products obtained is only from 40 to 45% of the calorific value of the fuel used. In the production of pig iron, the economy of fuel utilization is even lower, and the same is true of practically all other production processes used by large fuel consumers. In addition to their low efficiency, existing methods of fuel utilization are also characterized by low industrial concentration, leading as a rule to separate industrial plants of small size, and to high initial and labour costs.

The consumption of 100 million tons of fuel for industrial purposes by existing methods leads to the waste of 50 million tons expended on internal consumption and on making good direct heat and fuel losses. The combined system of processing and power generation described in this article could result in an economy which, with the same quantity of fuel, would yield an additional 80,000 million kWh of electrical energy.

This combined system of fuel utilization is based on the special physical and chemical properties of the high-energy process of burning fuel. The properties of the process of solid combustion may be summarized as follows: —

(1) The high temperature necessary for a number of conversion processes is attained.
(2) The heat energy can be used with equal efficiency for both processing and power generation.
(3) Any grade and type of low-quality fuel, including coke breeze and dust, can be employed in boiler furnaces with adequate effectiveness.
(4) The high-energy process of burning solid fuel in powder form is the only one which can be accomplished at high intensity and with practically complete combustion. Both intensity and completeness of combustion improve with a reduction in the particle size of the powdered fuel.

The simplest scheme for the utilization of fuel in the combined processing and power system is that of thermal conversion of the fuel immediately before its combustion. However, the large size and various imperfections of existing industrial furnaces do not make such a simple scheme effective for the purpose. Only the development of high-intensity methods of thermal pretreatment, in association with direct combustion of the solid residue, permits the practical development of the simplest method of combined processing and power utilization of fuel.

High-intensity thermal pretreatment is based on the following propositions :—

(1) Thermal dissociation includes two fundamental processes, i.e., heating of the mass of the fuel, and its chemical transformation.
(2) The chemical transformation taking place in the fuel consists of a series of simultaneous and consecutive reactions which have different kinetic characteristics.
(3) The presence of several reactions permits, in principle,

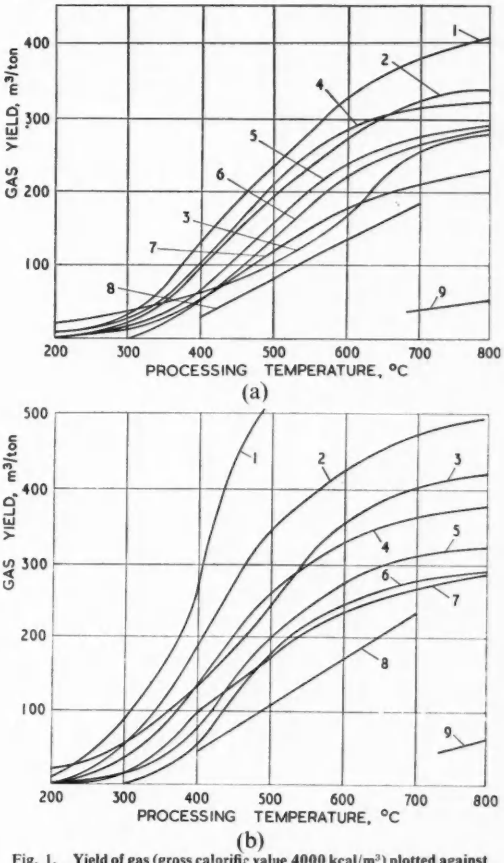

Fig. 1. Yield of gas (gross calorific value 4000 kcal/m³) plotted against temperature of thermal dissociation of solid fuels, (a) without pyrolysis, and (b) with pyrolysis of 75% of the tar.
(1) Shale.
(2), (4), (5), (7), (8) Bituminous coals from Russian fields.
(3) Peat.
(6) Donetz lean bituminous coal.
(9) Donetz anthracite.

control of the quality and yield of the products obtained, by creating the most favourable conditions for the preferred progress of desirable reactions.

(4) Control of the process is possible only when associated with rapid heating of the fuel mass taking part in the reaction. Slow heating virtually precludes the possibility of controlling the primary processes of thermal fuel dissociation. In existing industrial furnaces, in which large-size solid fuels are used, and when heating through walls, the fuel is heated slowly and non-uniformly. Consequently, control of the quality of the products obtained is greatly limited.

(5) Rapid heating of the fuel by means of a gaseous or a solid carrier of heat can be accomplished only when using small particles of fuel. The high-intensity controlled process of thermal dissociation can thus be ensured by using a rigorously maintained temperature sequence throughout. In this way, the distribution of the initial heat energy of the fuel through the gas, tar, and solid residues can be controlled within wide limits.

Some idea of the quantity of gas which can be obtained in the ordinary thermal conversion of different fuels is given in Fig. 1, where the variation in gas yield (per ton of combustible substance in different fuels) is plotted against the temperature of thermal dissociation in the case of slow heating of fuels, both without pyrolysis and with pyrolysis of 75% of the tar.

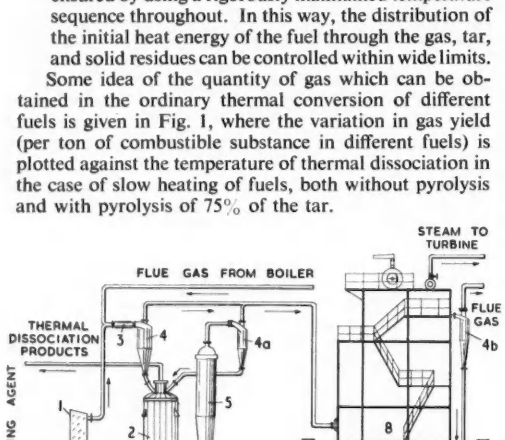

Fig. 2. The simplest scheme for the combined processing and power utilization of fuel, using both gaseous and solid heat carriers.

As a result of theoretical and experimental investigations, new methods of efficient thermal fuel conversion have been developed. The basis of these methods is the principle of intensive heating of small particles of fuel, either granular or powdered, by means of both gaseous and solid heat carriers, as neither the gaseous nor the solid heat carrier by itself appears to yield optimum results in the treatment of most grades of fuel. In this combined method, the part played by the gaseous heat carrier can be varied from that of partial drying of the fuel up to complete drying with heating up to 250°C, and almost 100% completion of heating of the fuel.

The best conditions for the combined heat-carrier system are obtained when using fuel in the form of a coarse-grained powder (with a grain size up to 2 mm). Under these conditions it is possible to utilize the gaseous heat carrier to the fullest extent. The proportion of heat introduced by the gaseous heat carrier can be expressed by a coefficient G. The larger is this coefficient, the more compact as a rule will be the plant used and the simpler will be the control of the product obtained.

Fig. 2 shows an example of the simplest scheme for applying the method of thermal conversion with the aid of a combined heat carrier for the processing and power utilization of fuel. Coarse-grained fuel powder, powdered in a mill (1), is heated by flue gas in a retort (3) to a temperature of 350 to 500°C, according to the grade of fuel used, and is then separated from the flue gas in a cyclone (4). The flue gas is led into the boiler furnace (8), while the fuel is rapidly transported into the thermal dissociation chamber (2), where it is mixed with hot powdered coke and attains the prescribed optimum temperature for thermal dissociation, between 550 and 750°C. The heated fuel powder dissociates, and the gas-vapour mixture formed, consisting of gas, water, and tar, is led off to the scrubbing and condensation plants. The solid residue of the fuel, i.e., coke and semi-coke, and the powdered coke mixed with it, are transported by a screw conveyor (6) or other means to the processing furnace (5), where they are partially burnt, thereby maintaining in this furnace a temperature of 800 to 1100°C. On leaving the processing furnace, the grains of hot coke residue are separated in a cyclone (4a) and returned to the thermal dissociation chamber (2) for the final heating of the original powdered fuel. The fine fuel powder, together with the hot gas, is fed into the boiler furnace (8) for burning. The process of combustion in the furnace takes place at high intensity, as the hot, fine, powdered fuel can be burnt with a heat release of several millions of kcal/m³ of the furnace per hour. The fly-ash in the flue gas is separated in a cyclone (4b), and, together with ash from the furnace, is passed through a ball-mill (7).

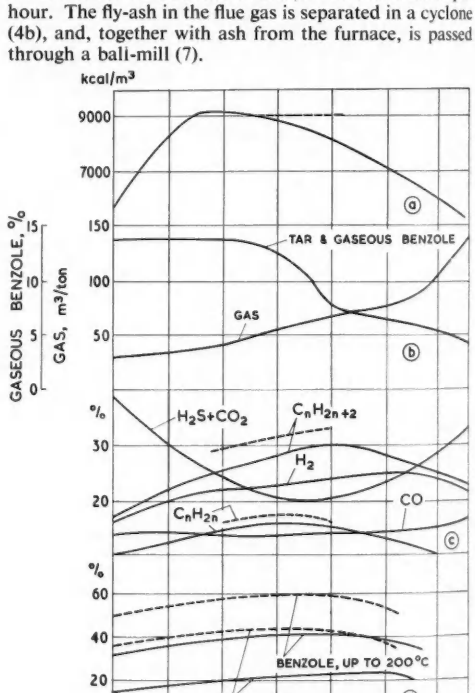

Fig. 3. Thermal conversion of Volga shale by a combined gaseous and solid heat carrier (G = 0·4 to 0·7).
(a) Calorific value of gas.
(b) Yield of tar and gaseous benzole.
(c) Percentage composition by volume of gas.
(d) Yield of tar fractions (including gaseous benzole).
Solid lines: Without pyrolysis.
Dotted lines: With pyrolysis.

Pilot plants burning from 30 to 250 kg/hr have been operated with a large variety of Russian fuels, ranging from peat and shale to different types of bituminous coal. Of particular interest are the results obtained for peat, which yields up to 300 m³ of gas per ton, with a calorific value of 5300 kcal/m³, instead of the normal value for peat of 3000 kcal/m³. The tar and gaseous benzole are claimed to yield a high-quality motor-spirit, i.e., up to 4% by weight related to dry peat, while, from 1 ton of dry peat, up to 12 or even 15 kg of benzole and toluol are stated to be obtained.

By way of example, Fig. 3 shows the yields of gaseous benzole and tar obtained from Volga shale (combustible content 26%) at different temperatures in the thermal dissociation chamber. The calorific value of this gas attains 6000 to 9500 kcal/m³, as against the normal 4000 kcal/m³. Fig. 4 shows curves illustrating the influence of temperature on the yield of different gaseous constituents and on the distribution of gross calorific value in the products of dissociation.

Another pilot plant with a high G coefficient has been operated with a wide variety of solid fuels. Figs. 5 and 6 show the yield, gas composition, total heat distribution, etc., obtained in the processing of bituminous coal powder from the Moscow region.

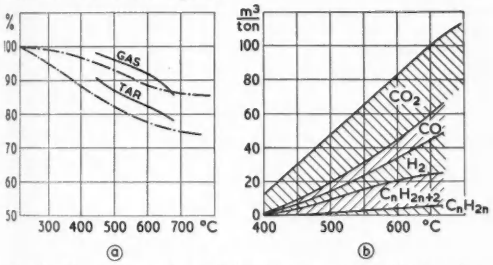

Fig. 4. **Thermal conversion of Volga shale by a combined heat carrier (G = 0·4 to 0·7).**
(a) Distribution of gross calorific value in the products of dissociation.
(b) Yield of different gaseous constituents in m³/ton of dry shale.
Chain-dotted lines: Slow heating in laboratory plant.

For the purpose of processing and power utilization of timber waste, another pilot plant was developed, involving the combustion of large-size particles of fuel arranged in layers and the use of a part of the gas for the thermal conversion of the timber. However, the quality of the gas obtained is considerably lower in this process.

Various specific projects are now in the design stage or are under consideration to introduce this sytem of combined processing and power utilization for peat, shale, and bituminous coal. At first, it was feared that there might be a danger of explosion, but this turned out to be unfounded, inasmuch as, from the point of view of its explosive tendency, powdered coke heated above its ignition point is completely safe, because in this condition an accumulation of air mixed with the powder in pipes and cavities is impossible. It should, however, be mentioned that a number of difficulties will undoubtedly have to be overcome when engineering large-scale installations of this type.

Several advantages of the new scheme apply particularly to its use in power stations now operating with

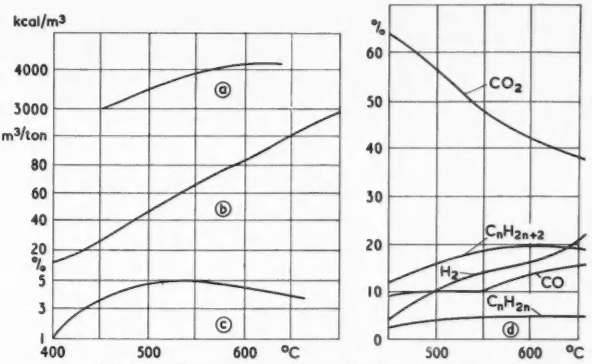

Fig. 5. **Thermal conversion of bituminous coal from the Moscow region by a combined heat carrier (G = 0·7 to 1·0), with heating by the the gaseous carrier not exceeding 520°C.**
(a) Calorific value of gas.
(b) Yield of gaseous constituents in m³/ton of dry coal.
(c) Percentage yield of tar.
(d) Percentage composition by volume of gas.

pulverized coal, as the cost of pulverization is reduced by the substitution of coarse-grain for fine-grain particles. Operation with hot powdered coke permits a new approach to boiler-output control, as the boiler can, under these conditions, operate at quite small loads without the danger of burner extinction. Furthermore, large fluctuations in the moisture content of the fuel have a far smaller effect on boiler operation, while in many plants using fuel with a high sulphur content it will be possible to prevent atmospheric pollution by sulphur dioxide without the need for costly scrubbing plant. The presence of an internal supply of gas with a high calorific value and of liquid fuel may, in certain cases, have an important effect on the operational reliability of the station.

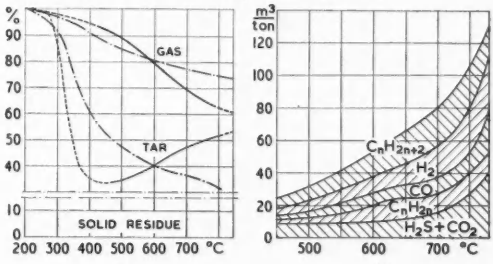

Fig. 6. **Thermal conversion of bituminous coal from the Moscow region by a combined heat carrier (G = 0·7 to 1·0), with heating by the gaseous carrier not exceeding 520°C.**
(a) Distribution of gross calorific value in the products of dissociation.
(b) Yield of different gaseous constituents in m³/ton of dry coal.
Solid lines: Plotted from plant data.
Chain-dotted lines: Plotted from laboratory data, with a heating rate of 2·5°C/min.

Finally, it should be noted that the feeding of hot fuel into the furnace is an important factor, permitting considerable intensification of the combustion process. As a result of its further reduction in size during the process of thermal conversion, the hot powder entering the boiler furnace is very finely divided, the predominant grain size being less than 50 microns, and combustion of this powder can be carried out with a heat release of the order of several millions of kcal/m³ per hour. In the case of a

(*Concluded on page* 80)

GERMANY

Similarity Considerations for Rotodynamic Machines

By O. CORDIER. (From *VDI-Zeitschrift*, Vol. 97, No. 34, December 1, 1955, pp. 1233-1234, 2 illustrations.)

IN the design of rotodynamic or flow-type machines, good results have been achieved by employing non-dimensional parameters derived from Bernouilli's theorem. Test data can also be presented in non-dimensional form by means of the pressure parameter

$$\psi = 2gH/u^2 = 2gH/(\pi Dn/60)^2 \quad .. \quad .. \quad .. \quad (1)$$

and the delivery parameter

$$\varphi = 4Q/(\pi D^2 u) = 240\,Q/(\pi^2 D^3 n) \quad .. \quad .. \quad (2)$$

where D = rotor diameter [m], u = peripheral speed of rotor [m/sec], n = rotor speed (rpm), g = acceleration due to gravity = 9·81 m/sec², H = head [m], and Q = delivery [m³/sec]. With ψ and φ, it is possible to estimate from a series of test results the expected performance at other speeds or for different sizes of rotors of a geometrically similar type.

In the design stage, the operating conditions (H and Q) are usually specified, and it is required to find suitable values of D and n. It therefore also appears convenient to make these "design parameters" non-dimensional.[1]

At present in use are the so-called " specific speeds "

$$n_s = nN^{\frac{1}{2}}/H^{\frac{5}{4}} \quad .. \quad .. \quad .. \quad (3)$$

and $$n_q = nQ^{\frac{1}{2}}/H^{\frac{3}{4}} \quad .. \quad .. \quad .. \quad (4)$$

where N = shaft horse-power. Although these permit assessments to be made, they are not non-dimensional; moreover, n_s also depends on the density of the fluid. A general parameter should depend neither on the material constants nor on the choice of the units used for measurements. As a result, it has been proposed by Spannhake[2] that use be made of a " specific angular velocity "

$$\omega_s = \omega\, Q^{\frac{1}{2}}/(2gH)^{\frac{3}{4}} \quad .. \quad .. \quad .. \quad (5)$$

while Keller[3] suggested a velocity parameter

$$\sigma = (2n\sqrt{\pi}/60)Q^{\frac{1}{2}}/(2\,g\,H)^{\frac{3}{4}} \quad .. \quad (6)$$

where $\omega = 2\pi n/60$ [rad/sec]. Both expressions fulfil requirements and differ from one another only by a constant factor, since $\omega_s = \sqrt{\pi}\,\sigma$.

For a wide range of applications (pumps, fans, compressors, etc.) it will be useful to derive a non-dimensional expression for the rotor diameter. If eqs. (1) and (2) are rearranged and solved for D and n respectively

$$n = (60/2\sqrt{\pi})\,\varphi^{\frac{1}{2}}(2g\,H)^{\frac{3}{4}}/(\psi^{\frac{3}{4}}\,Q^{\frac{1}{2}}) \quad .. \quad (7)$$

and $$D = (2/\sqrt{\pi})\,\psi^{\frac{1}{4}}\,Q^{\frac{1}{2}}/[\varphi^{\frac{1}{2}}\,(2gH)^{\frac{1}{4}}] \quad .. \quad (8)$$

By isolating the non-dimensional quantities on the right-hand side of eqs. (7) and (8), two new parameters are obtained, i.e.,

$$\sigma = \varphi^{\frac{1}{2}}/\psi^{\frac{3}{4}} \qquad \text{and} \qquad \Delta = \psi^{\frac{1}{4}}/\varphi^{\frac{1}{2}}$$

Then, σ yields the same expression as eq. (6), while the " specific rotor diameter " is obtained as

$$\Delta = D\,(\sqrt{\pi}/2)(2gH)^{\frac{1}{4}}/Q^{\frac{1}{2}} \quad .. \quad .. \quad (9)$$

As σ is identical with the expression derived by Keller in a different manner, it will be retained in preference to ω_s. The parameter Δ has a physical significance ; it represents the ratio of the rotor diameter to the diameter of an equivalent substitute nozzle.

Thus, instead of the parameters φ and ψ representing the operating conditions, it is possible to employ the design parameters σ and Δ as abscissae and ordinates in diagrams of measured results, and as a basis for projects of new machines.

A (specific) velocity/diameter diagram is reproduced in Fig. 1, and shows the working points of 120 fans, compressors, and pumps of axial and radial types. The narrow region of scatter of these working points makes it possible to recognize the law relating diameter to speed for specified working conditions. Fig. 1 also contains calculated efficiency curves for single-stage axial compressors, taking account of blade-friction and exit losses. It is apparent that axial-flow compressors (approximately above σ = 0·5) allow more latitude than radial-flow compressors (approximately below σ = 0·5) in the choice of a diameter for a specified running speed, without deviating appreciably from optimum efficiency. Radial compressors and pumps are concentrated in a strip between ψ = 0·8 and 1·5 approximately. With

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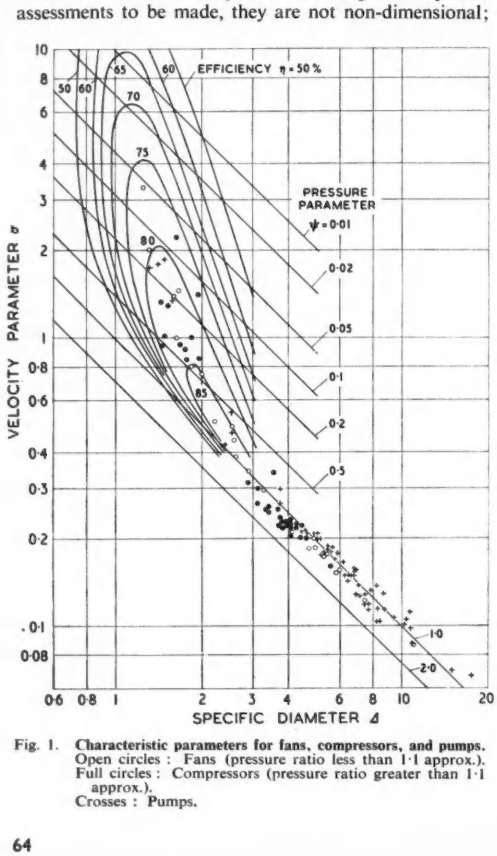

Fig. 1. **Characteristic parameters for fans, compressors, and pumps.** Open circles : Fans (pressure ratio less than 1·1 approx.). Full circles : Compressors (pressure ratio greater than 1·1 approx.). Crosses : Pumps.

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Stresses in Pressure Vessels

By W. P. KERKHOF. (From *De Ingenieur*, Vol. 67, No. 45, November 11, 1955, pp. W.131-W.138, and No. 46, November 18, 1955, pp. W.141-W.148, 16 illustrations.)

(*Continued from January issue*)

(9) DEFECTS IN THE WELD (*continued*)

Fig. 5a shows part of the stress range of a cylindrical shell without cracks (*OQ*). In the same figure a tensile-compression curve $N'H'C'O\ A\ B\ N$ is given, representing the stress at the edge of the sharp crack shown in Fig. 5b.

Without a crack, the stress range shown in Fig. 5b is the sum of the membrane stress *I–I* and the stress due to out-of-roundness, resulting in a total stress *II–II*.

If the dimensions of the crack are small compared with the amount of surrounding sound material, it is obvious that the crack will be forced to follow the movement of the sound material during loading and unloading. The strain in the root of the crack will thus be the same as the strain in the material without notch. This strain is caused by the stress range *ST*, and is shown in Fig. 5a as the line *OS*.

The real stress near the crack is already 2·5 times the yield point at the slightest load. This stress curve is shown in Fig. 5b (curve $I'AA'$). The maximum stress *OA* under a very small load is also shown in Fig. 5a. If the load is now increased to such a value that the total strain equals *OS*, the stress in the root of the crack is forced to follow the curve *AB*. This means that not only does strain-hardening occur, but also that the sharp edges of the crack have been slightly rounded off, thereby enabling the material to follow the movement *OS*.

During unloading the stress follows the straight line *BC*. At point *C* reverse yield occurs, so that during further unloading the line *CD* parallel to $C'D'$ is followed. The line *BC* is less steep than *OA*, owing to the fact that the root of the crack has slightly rounded off, as shown in Fig. 4 by the difference between curves *C* and *B*. During reloading, the line *DE* parallel to *BC* is first followed, and then *EF*, parallel to BF'. Some strain-hardening has again occurred, and the root of the crack is slightly more rounded off. During further loading and unloading the lines *FG*, *GH*, *HK*, *KL*, etc., respectively are followed. After a certain number of stress cycles the limit will be reached, and the stress varies between M' and *M*. No further yielding or strain-hardening occurs ; the following stress cycles are fully elastic. Consequently, the stress *MS*, as shown in Figs. 5a and 5b, is now dependent on the load or the strain *OS* and on the plate thickness. If *MS* is greater than the rupture or fatigue stress *NP*, rupture occurs ; if *MS* is smaller than *NP*, no rupture occurs.

When a weld efficiency factor is introduced, for instance for a non-radiographed vessel, the plate thickness will be greater than before, as shown in Fig. 5c. According to the previous theory, however, the stress values in the cylindrical shell are about the same in the case of both thick and thin plate. This means that the strain *OS* does not alter. The maximum stress occurring after a certain number of stress cycles is now again totally elastic and is also dependent on the same strain *OS* and the plate thickness.

It is known, however, that, given the same dimensions of crack and the same mean strain, the thicker the plate the greater will be the elastic stress in the root of the crack. Consequently, the stress M_tS_t will be greater than *MS*. It is also known that the tensile properties and probably the fatigue properties will be less for a thicker and greater for a thinner plate, assuming both plates to be made from the same material. This means that the rupture stress N_tP for the thick plate will be smaller than the stress *NP* for the thin plate.

Introduction of a weld efficiency factor therefore increases the tendency to rupture. Furthermore, the thicker the plate, the more difficult it is to weld and the greater the tendency to crack. Consequently, a weld efficiency factor has an adverse effect on the strength of a cylindrical shell and should not be introduced into the calculation. The plate thickness should be as small as possible, or as close as possible to the limits given by eqs. (1) or (2b).

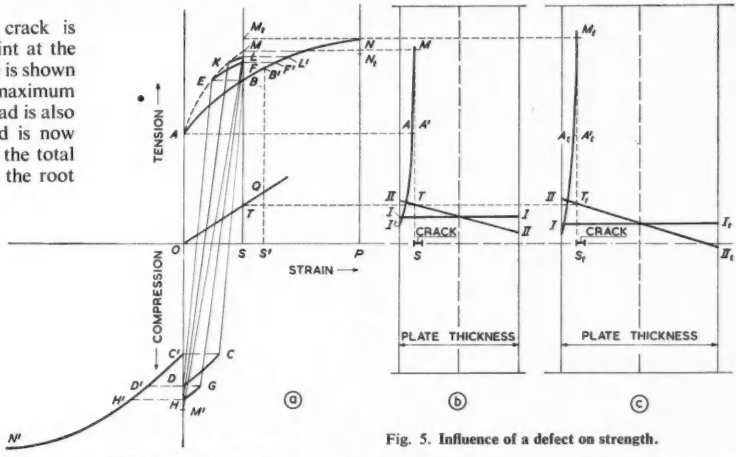


Fig. 5. **Influence of a defect on strength.**

This conclusion remains valid when internal stresses occur. The present theory is based only on the stress range, which is independent of the internal stresses. The stress range near the notch is so great that the internal stress vanishes totally during the first loading. Non-stress-relieved vessels should therefore also have a weld efficiency of 100%.

From this theory it follows that there is no relation between hydrostatic tests and rupture in service. During the hydrostatic test the strain OS' will be higher than *OS*. The corresponding stress $B'S'$, however, is in nearly all cases lower than the stress *MS* occurring after a certain number of stress cycles.

It is furthermore now clear that, if a crack is formed owing to corrosion, the stress range increases, causing rupture after a certain number of stress cycles, as mentioned in section 6.

(10) Calculation of the Allowable Stress Range at 343°C for Localized Stresses in Carbon Steel

In this case it is assumed that the parts subject to high stresses are surrounded by fully elastic material, so that eq. (2b) applies. It seems logical to use eq. (2b) without a safety factor, assuming that the theory put forward is true. On the other hand, it will be seen that some factors have to be used, in order to guarantee safe operation. These factors, however, are not safety factors. The real difference between them and a safety factor is that they can be logically estimated or calculated.

Attention is drawn to the theory described in section 3. This theory is based on the fact that repeated yielding, in compression and/or tension, should not occur. This characteristic of behaviour will be used in establishing some of the factors mentioned. If the theory under consideration is accepted, eq. (2b) can be used for the design, provided that the total stress range is known and that no other phenomena interfere with the theory. A special phenomenon, however, which has an influence on eq. (2b), is stress relaxation at higher temperatures. It is known that at higher temperatures, say, above 300°C, stress decreases gradually with time. Relaxation tests have shown that, at the temperature under consideration (343°C), when there is no restriction on relaxation, the total initial stress (= yield point) relaxes to about 75% of the original value. In reality, there are restrictions on relaxation, since only the statically indeterminate stresses can relax. As only some of the stresses can relax, the stress after relaxation at 343°C is greater than the 75% mentioned in the test above. If, however, the 75% mentioned is accepted for calculation, the assumption is on the safe side. To obtain more accurate values, further investigations have to be carried out.

Owing to relaxation, the following occurs :—In Fig. 6a the stress range is supposed to be too great, but smaller than $2\sigma_{y343}$, where σ_{y343} is the minimum yield point at 343°C. The theoretical elastic stress is equal to BC', and the real stress just after loading equals CC'. Owing to relaxation this stress decreases to $DC' \geqq 0{\cdot}75\ CC'$ approximately. During unloading the theoretical stress follows the line DF. However, at point E reverse yield occurs, so that the real stress follows the lines DEG. During subsequent stress cycles reverse yield occurs, until point F, corresponding to point H of the stress-strain curve, is reached. It is clear that, owing to relaxation, repeated yielding may occur in the non-loaded conditions, resulting in a brittle material.

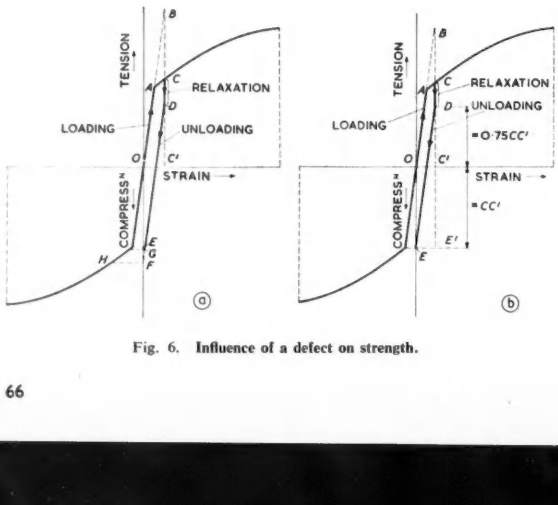


Fig. 6. **Influence of a defect on strength.**

No reverse yield occurs, according to Fig. 6b, if the stress range due to load ($C'B = E'D$) plus the relaxed stress DC is smaller than or equal to about $2\sigma_{y343}$, or if

$$\sigma_{tot} \leqq 1{\cdot}75\sigma_{y343} \quad .. \quad .. \quad .. \quad (6)$$

or

$$1{\cdot}14\,\sigma_{tot} \leqq 2\sigma_{y343} \quad .. \quad .. \quad .. \quad (6a)$$

This means that the stress range should be smaller than it is according to eq. (2b).

The relaxation seems to be a disadvantage from the point of view of the allowable stress range. As regards corrosion, the relaxation is advantageous, because the total stress, including the residual stress, diminishes gradually with time.

At high temperatures, temperature stresses always occur. In the case of vessels insulated in the usual way, the temperature stresses during service can be ignored. During the heating-up and cooling-down periods, however, extra temperature stresses occur which cannot be ignored. It is obvious that the temperature stress can be 14% (eq. (6a)) of the stress range without doing any harm. This value seems high enough. In many codes the allowable pressure accumulation during blowing of the safety device is 10%.

It will now be clear that eq. (6) or (6a) can safely be used for the calculation. The stress range σ_{tot} now refers only to the stress range due to the internal pressure. In all cases a factor still has to be used which expresses the accuracy of the strength formula. The final form of eq. (6) may thus be as follows :—

$$\sigma_{tot} \leqq 1{\cdot}75\alpha\sigma_{y343} \quad .. \quad .. \quad (7)$$

The factor α equals unity in very accurate strength formulae. In other, less accurate, formulae α is smaller than unity. The value of α can be found by comparing calculated with measured stresses. Furthermore, α includes the effect of manufacturing tolerances.

(11) Calculation of the Allowable Stress Range at Temperatures below 343°C for Localized Stresses

It is reasonable to assume that eq. (2b) applies at all temperatures. At atmospheric temperature neither extra temperature stresses nor a stress relaxation occur. It is, however, necessary to reckon with a 10% pressure accumulation. Consequently, eq. (7), which allows 14% accumulation, is slightly on the safe side, and may be used.

The general equation valid for all temperatures below 343°C and above the transition temperature is thus

$$\sigma_{tot} \leqq 1{\cdot}75\alpha\sigma_{y} \quad .. \quad .. \quad .. \quad (8)$$

The hydrostatic test is also carried out at atmospheric temperature, at a pressure higher than the working pressure. As the high stress during the test occurs only once, and the stress under consideration is presumed to be so local that severe deformation cannot occur, no strain-hardening will occur during the test. Consequently, the influence of the hydrostatic test can be ignored.

(12) Comparison with Established Practice

The local stress ranges under consideration occur, for instance, in drumheads. A study of the stresses in drumheads is very attractive because of the following :—

(a) An exact calculation of the stress is possible.

(b) Many stress measurements have been carried out on the outer surface as well as on the inner surface. (In order to be sure of the measures stresses, only measurements carried out externally as well as internally have been taken into account.)

(c) In the oil industry many drumheads have been used at temperatures of about 343°C, where the design membrane stress is $0{\cdot}72\ \sigma_{y343}$. It should be stated here that in the oil industry there is a preference for ellipsoidal heads with a depth-to-diameter ratio of 0·25. Although shallower heads have also been used, most experience has been gathered from the use of ellipsoidal heads.

(d) In many cases the head has no weld. Consequently, no weld efficiency factor has been used for the calculation.

(e) As far as the author knows, no rupture of a drumhead has ever occurred, the conclusion from which is that the stresses used in the A.P.I.-A.S.M.E. code are permissible.

In many codes the stress has to be calculated by using a simplified formula

$$\sigma = C\frac{PD}{2t} \qquad .. \quad .. \quad .. \quad (9)$$

where P is the internal pressure, D the external diameter, t the head thickness, σ the stress occurring, and C a factor dependent on d/D, where d is the outside depth of the drumhead. As already stated, this equation should be combined with eq. (8). In this case the factor C should be chosen in such a manner that σ represents the equivalent uni-axial stress range σ_{tot} according to the shear strain energy theory. For purposes of comparison with real stress measurements or very accurate calculations, the factor α in eq. (8) is equal to unity.

As $PD/2t$ equals the membrane stress σ_m' in the cylindrical shell, eq. (9) can be written as follows :—

$$\frac{\sigma_{tot}}{\sigma_m'} = C \qquad .. \quad .. \quad .. \quad (10)$$

Comparisons of values of C for accurately calculated and measured drumheads with those calculated from the A.P.I.-A.S.M.E. code formula show that the real maximum stresses occurring can be about 2·5 times as high as those allowed by the A.P.I.-A.S.M.E. code, according to which the allowable stress is $0{\cdot}72\ \sigma_{y343}$ at 343°C. The real stress in a domed end can thus be $1{\cdot}80\ \sigma_{y343}$.

According to the proposed formula (assuming $\alpha = 1$), the allowable stress is $1{\cdot}75\ \sigma_{y343}$ (eq. (6)). It is obvious that the proposed calculated allowable stress is on the safe side.

It is worth while checking the formulae for atmospheric temperature as well. This is not possible in the case of drumheads, because the allowable stresses at atmospheric temperature, according to the A.P.I.-A.S.M.E. code, are too low compared with those allowed in eq. (8). Fortunately, a comparison with flanges makes it possible to check eq. (8). Here also, the A.P.I.-A.S.M.E. code will be chosen for this comparison, because many vessels exist in the oil industry which are subjected to rather high pressures at atmospheric temperature. Furthermore, for the calculation of flanges, no weld efficiency has to be taken into account, and, here again, the basis of comparison is real.

At atmospheric temperature the allowable stress in the hub of a flange, according to the A.P.I.-A.S.M.E. code, is $\sigma = \frac{3}{8}\sigma_u = 0{\cdot}65\ \sigma_y$.

According to the code mentioned, the allowable stress for carbon-steel bolts is 7000 psi (4·9 kg/mm²).

Accurate bolt stress measurements of carbon-steel bolts have proved that all bolts are stressed up to the yield point, which is at least four to five times as high as the assumed stress in the bolts. Consequently, the stress range in the hub will also be about four to five times the calculated stress, or $2{\cdot}60\ \sigma_y$ to $3{\cdot}25\ \sigma_y$, which is appreciably higher than the stress according to eq. (8). The stress in a flange can be calculated very accurately, so that α may be taken equal to unity.

As far as is known, rupture has never occurred in the hub of a flange. It is thus clear that eq. (8) gives very safe stress values for flanges at atmospheric temperatures. However, in this case, eq. (8) may also be used at atmospheric temperatures and other temperatures for domed ends, etc.

(13) Calculation of the Allowable Stress Range for a Cylindrical Shell at 343°C.

The stresses in a cylindrical shell are not localized, but are distributed over a large area. As strain-hardening ought to be avoided, in this case the total stress range should not cause yielding throughout the whole thickness of the plate. Consequently, the stress range should be much smaller than it is according to eq. (8). Whether or not yielding occurs throughout the whole plate, thickness can be calculated with eq. (1).

In section (7) it was proposed that the out-of-roundness should be limited in such a way that the extra bending stress σ_b does not exceed $\frac{2}{3}\sigma_m$. When $\sigma_b = \frac{2}{3}\sigma_m$ in eq. (1), yielding occurs throughout the entire plate thickness if

$$\sigma_m = 0{\cdot}81\ \sigma_{y343} \qquad .. \quad .. \quad (11)$$

or

$$\sigma_{tot} = \sigma_m + \sigma_b = 1{\cdot}35\ \sigma_{y343} \qquad .. \quad (11a)$$

In the same manner as for local stresses, the question whether some restrictions are still necessary now has to be investigated. First of all, as regards the cylindrical shell, the formulae used for calculating the stresses are in agreement with stress measurements. The measurement of the out-of-roundness as described in section 7 is on the safe side. The calculated stresses are therefore obviously on the safe side, in consequence of which no extra factor α has to be included to compensate for inaccuracy of the stress formula.

Furthermore, σ_{tot} should be the equivalent stress, according to the shear strain energy theory, which is not the case in eqs. (11) and (11a). If the shear strain energy theory is applied, the factors 0·81 and 1·35, of eqs. (11) and (11a) respectively, will be slightly greater. Consequently, these equations are on the safe side, despite the fact that they are a rather rough approximation.

The total stress ($1{\cdot}35\ \sigma_y$) is about 77% of the value $1{\cdot}75\ \sigma_y$ allowed for local stresses (eq. (8)). Consequently, reverse yield after relaxation at high temperatures cannot occur.

In section 10 a factor of 1·14 has been used, not only for the relaxation but also to allow some extra temper-

ature stresses during heating up and cooling down. If the same factor is used here, the allowable stress will be

$$\sigma_m = \frac{0{\cdot}81}{1{\cdot}14}\sigma_{y343} = 0{\cdot}71\sigma_{y343} \quad .. \quad (12)$$

and

$$\sigma_{tot} = \frac{1{\cdot}35}{1{\cdot}14}\sigma_{y343} = 1{\cdot}20\,\sigma_{y343} \quad .. \quad (12a)$$

It is obvious that at the same time a sufficient allowance for 10% pressure accumulation during blowing of the safety device has been included.

The allowable membrane stress $\sigma_m = 0{\cdot}71\ \sigma_{y343}$ is in such close conformity with the stress allowed according to the A.P.I.-A.S.M.E. code ($\sigma_m = 0{\cdot}72\,\sigma_{y343}$), that there will be no doubt that the proposed theory can be used.

(14) Calculation of the Allowable Stress Range for a Cylindrical Shell at Atmospheric Temperature.

Since at atmospheric temperature no temperature stresses occur, but the 10% pressure accumulation is still required, eqs. (12) and (12a) seem to apply.

At this temperature, however, the hydrostatic test is carried out. The stress under consideration is now distributed over a large area, and is not local. This means that yielding due to the test pressure may cause non-permissible strain-hardening. If the test pressure is assumed to be at most 1·3 times the working pressure, it is obvious that during this test non-permissible yielding and strain-hardening occur if eq. (12) is used. For the hydrostatic test the allowable stress should therefore be less than it is according to eqs. (12) and (12a).

Assuming at atmospheric temperature an allowable membrane stress

$$\sigma_m = 0{\cdot}60\,\sigma_y \quad .. \quad .. \quad .. \quad (13)$$

then the membrane stress at the test pressure is $0{\cdot}78\,\sigma_y$. Assuming the bending stress to be proportional to the pressure, which is not always true, $0{\cdot}78\,\sigma_y$ is about 97% of the stress causing yielding over the whole cross-section (eq. (11)).

Apart from the hydrostatic test, there are still other reasons why the allowable stress at atmospheric temperature should not be too high. These reasons can be summarized as follows :—

(a) The pressure accumulation should not be higher than the permitted 10%. However, this is only a calculated value for application to normal circumstances. In abnormal cases, for instance during a fire, the pressure accumulation may be considerably higher, i.e., 20 or 30%. Should the high stresses be local, an occasional high stress has no influence at all; only repeated high-stress cycles have any influence. For the cylindrical shell, however, the first time the stresses exceed the critical value of eq. (1), non-permissible strain-hardening occurs.

(b) If the material yields over the whole cross-section, a tri-axial state of stress, due to the difference in yield point between the weld and base material, occurs. This state of stress may be dangerous and should therefore not occur. At higher temperatures the difference in yield point between weld material and base material is less pronounced.

(c) The shape of the stress-strain curve at atmospheric temperature is quite different from the shape at, say, 343°C. Assuming that at both temperatures the stresses are given as a particular fraction of the yield point at working temperature, the deformation at the low temperature is much greater than at the high temperature. It seems that the deformation at the high temperature is still acceptable. At atmospheric temperature, however, the possible deformation is not acceptable.

(d) The stress relaxation occurring at high temperatures does not occur at atmospheric temperatures. The advantage of this stress relaxation for cylindrical shells is that not only does the total stress, including the residual stress, decrease gradually, but the extra stresses due to out-of-roundness decrease at the same time. As the high stress is distributed over a large area, the only possible way in which the bending stress mentioned can decrease is by a simultaneous decrease in the out-of-roundness. Consequently, the stress range also decreases. The calculated high-stress range at high temperatures therefore occurs only at the beginning of the life of a vessel, but soon decreases to a lower value. For this reason, at high temperature some extra safety, which is not available at atmospheric temperature, is provided.

(To be concluded)

Fabrication of Zirconium by Powder-Metallurgy Techniques

(*Concluded from page* 60)

of this same powder at 800°C. Prior to extruding, the powder was cold-pressed at 125 tsi in a mild-steel can retained in a hardened die. The can was then welded shut. No effort was made to evacuate the entrapped air. In the extrusion press, reduction ratios of 11 to 1 were made, and full-density rods resulted. The extruded rods were vacuum-annealed at 750°C for 30 min. With −80-mesh powder the Rockwell hardness was B-83 to 85, whereas +80-mesh powder produced somewhat softer rods, B-76 to 80. These same materials when arc-melted had hardnesses of B-94 and 89 respectively.

This zirconium can also be hot-rolled at 775°C into strong, dense sheets. To do this, cold-pressed compacts made from −80-mesh powder were jacketed in mild-steel containers and hot-rolled to a total reduction of 80%, resulting in full-density sheets. After a 1-hr vacuum-anneal at 750°C, the sheet showed a hardness of B-88 and had a transverse rupture strength of 200,000 psi.

Conclusions

As zirconium is highly reactive with most gases at fairly low temperatures, special techniques have had to be developed to handle the powders and compacts. The knowledge gained from this work will be of considerable value to investigators dealing with other reactive metals. The advantage of pressing and sintering zirconium hydride has been clearly brought out—a technique which ought to be of value for other metals, such as titanium and vanadium, which readily form a hydride.

The powder metallurgy of zirconium and the evaluation of the products are not so highly developed as for beryllium. More work is needed on the various methods of preparing zirconium powder, the techniques of consolidation, and a detailed evaluation of the physical, mechanical, and chemical properties of the finished parts. No work has been done on the preparation of zirconium alloys by powder techniques and, in view of the beneficial effects of small alloying additions to zirconium, this, too, offers a fertile field for study.

British Industrial Developments

Cable Manufacturing and Testing Equipment

The Pirelli-General Cable Works Ltd., an associated company of The General Electric Co. Ltd. and Pirelli, Milan, have recently completed the installation of new facilities for the manufacture and testing of super-tension cables at their Eastleigh works.

A specially designed precision paper-lapping machine has been installed, capable of applying simultaneously up to 200 layers of paper insulation under precisely controlled conditions of tension and registration, by means of 20 reversible lapping heads, each capable of applying 10 papers. A close-up of one of these heads, showing paper tapes being applied to a 301-kV cable, is illustrated in Fig. 1. For safety in operation, all the lapping heads are partially enclosed by a transparent guard. The machine, which is 150 ft in length, is housed in a fully air-conditioned enclosure of about 40,000 cu ft, together with the paper-cutting machine and storage racks for the cut paper pads, so that the paper is properly conditioned before use. The entire lapping process can thus be carried out under constant controlled conditions of temperature and humidity.

The most important feature of the paper-lapping machine is the paper-tensioning device. Tension is imparted to the paper by means of a spring-controlled band-brake acting on the pad holder. The paper passes to the cable over four rollers, one of which is attached to the pivoted layer, which is itself spring-controlled and coupled by link-work to the band-brake. The paper tension is predetermined by selecting springs (which are interchangeable) of the requisite strength. Valuable properties of the paper-tensioning mechanism are that it is unaffected by centrifugal forces and that it maintains correct tension, even when the machine is stopped, and despite the slight, unavoidable backlash.

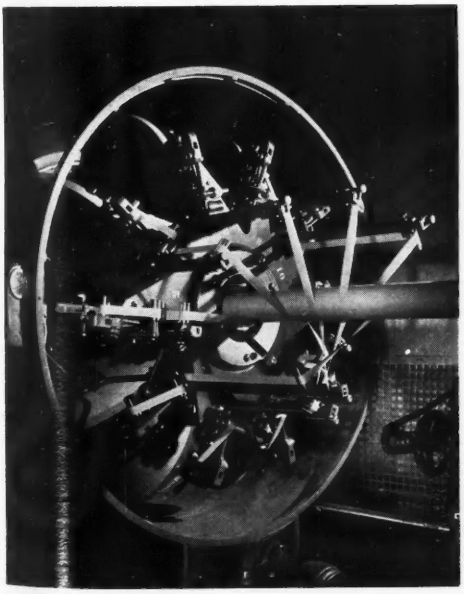


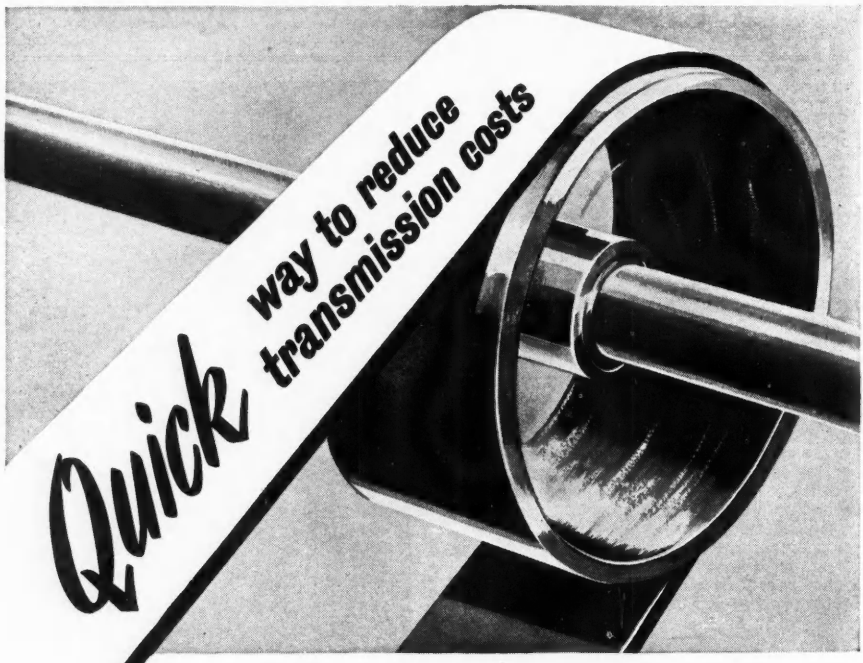
Fig. 1.

Fig. 2.

This equipment, the first of its kind to be used on full-scale production in Great Britain, enables a consistently high standard of electrical insulation to be automatically maintained, irrespective of external atmospheric conditions during manufacture.

New development and test bays associated with the electrical laboratory have been equipped with the latest apparatus for carrying out development work and type-approval tests on cables for the highest voltages. In this connection, the previous test facilities were moved to a new site and new equipment added. Thus, in the development bay, a Micafil impulse generator, with a stored energy of 38,500 W-sec and an open-circuit voltage of 1600 kV peak, has been installed. The generator is capable of applying impulses up to 1400 kV peak on samples of cables, including accessories, up to about 25 yards in length. A feature of the impulse generator, which is of Swiss design and manufacture, is its small size in relation to its output. Its design is somewhat unusual in that all the capacitors are contained in a central column of bakelized paper, instead of in several porcelain columns. The charging unit consists of a mechanical high-voltage rectifier operating at 200 kV d.c.

The impulse generator is remotely controlled from a desk in an elevated control room overlooking the testing bay. Also in the control room is a cathode-ray oscillograph for monitoring and photographing the applied impulses. Fig. 2 shows an impulse test on a 275-kV sealing end being observed and recorded in this control room. The control room and the entire floor of the test enclosure are screened by a wire-mesh counterpoise which, with all measuring circuit screens, is earthed at a single point close to the impulse generator. The generator can be moved on rails and is provided with four operating positions, each with a separate earthing electrode.



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Three-Stage Torque Converters

Rolls-Royce will shortly be in production with a range of 3-stage torque converters made under licence from the Twin Disc Clutch Company of America. Production of three sizes of torque converter is planned, covering the range of diesel-engine powers between 60 and 600 bhp. The three sizes are the Series 10,000, 11,500, and 13,800. These torque-converter transmissions, which enable an engine to run at or near its governed speed under all load conditions, are matched to suit Rolls-Royce oil engines in various applications.

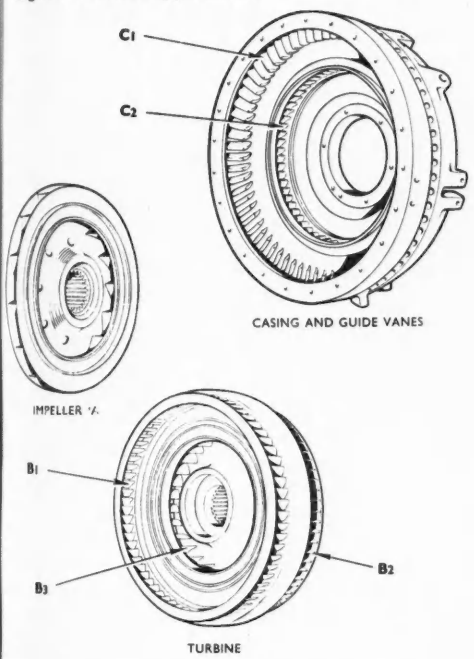


Fig. 1.

The Rolls-Royce torque converter works on the hydrodynamic principle with a centrifugal fluid pump or impeller driven by the engine, and a centripetal motor or turbine driven by the fluid. The turbine has three separate sets of vanes, each receiving jets of fluid in turn, with "reaction" or "guide vanes" attached to the stationary casing of the unit. The three basic parts of the converter are shown in Figs. 1 and 2. The impeller A which is driven by the engine, has one ring of blades which pump the fluid with which the converter is filled. The turbine, which is made up of three rings of blades B_1, B_2, and B_3, is connected to the output or driven shaft. The reaction or guide vanes are in two rings C_1 and C_2 attached to the stationary casing. Each of the three sizes of converter covers a wide range of engine powers by variation in blading. The torque multiplication at stall of the turbine can be as great as 5·3 times the input torque, and its torque ratio, output to input, can vary from 5·3 : 1 to 1 : 1 progressively.

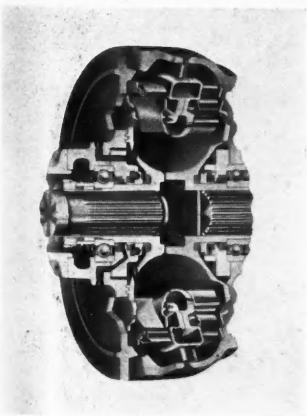
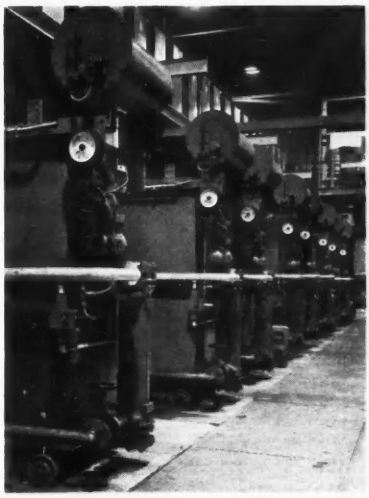


Fig. 2.

Rolls-Royce stress the importance of matching the converter, both to the engine and to the application or duty cycle for which it is intended. It is therefore essential that there should be complete co-operation and exchange of information between the manufacturer and the vehicle operator, so that the most efficient transmission can be fitted to suit the application.

Power-Plant for Titanium Melting Furnaces

The plant manufactured by the Westinghouse Brake & Signal Company to power the titanium melting furnaces of William Jessop & Sons Ltd. has been installed at the Brightside Works, Sheffield, and will shortly begin continuous service. This project is unique in that it is the first full-scale titanium process plant in Europe which uses power metal rectifiers and, moreover, the first in the world to employ the Westinghouse Series-Resonant circuit, offering the advantages of high efficiency combined with a wide range of output characteristics to give voltage/current gradients at the load operating point extending from $-1/80$ to $-1/8$. As an essential feature of the melting process is to preserve the operating-point gradient, the plant has current control at a constant voltage. The current range is from 0 to 18,000 A and this holds for any selected voltage between 0 and 40 V. The illustration shows the line of nine rectifier tanks, each of 2000 A.



The equipment is rated to work continuously. The Westalite rectifier assemblies are forced oil-water-cooled with the transformers oil-immersed and naturally air-cooled. Switchgear and other auxiliary circuit components are air-cooled to be in accordance with the site layout and special processing technique. The control panel is arranged so that each furnace operator has the full range of controls immediately around him, but is not distracted by any other operators.

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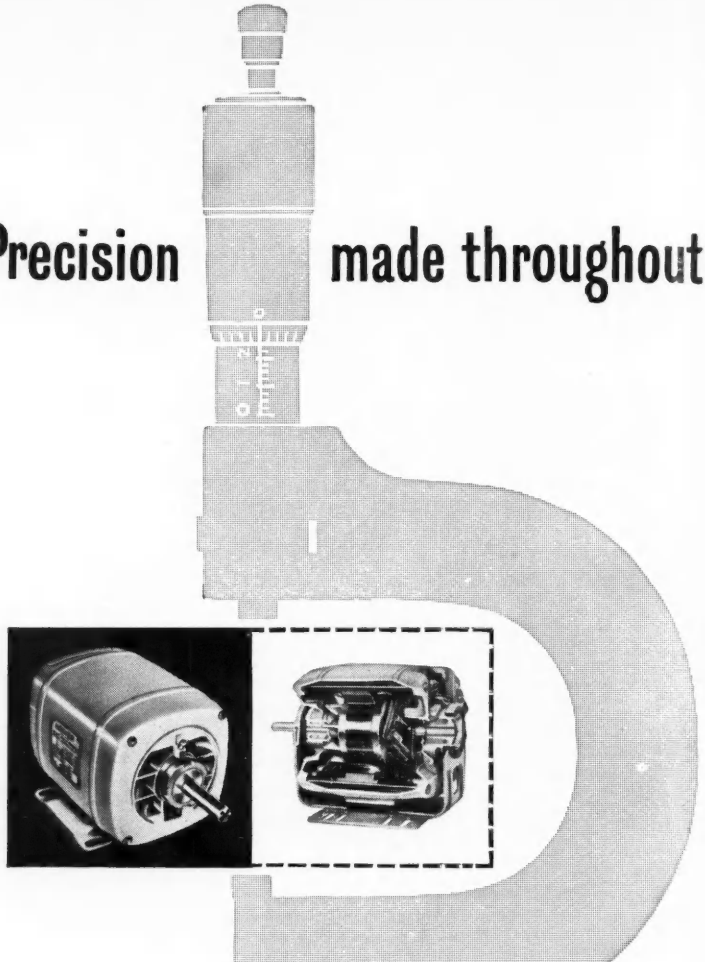

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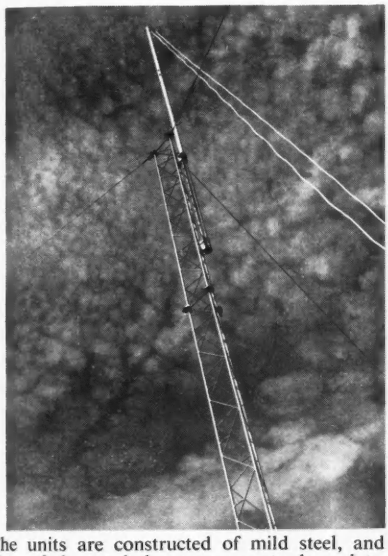
Unit Radio Mast

To meet the demand for a stayed mast which is cheap, light, transportable, climbable, and easily erected, British Insulated Callender's Construction Company Limited, of London, W.C.1, have developed a design which is to be known as the Unit Radio Mast and is being mass-produced by Painter Brothers Ltd., of Hereford.

Consisting of 10-ft units, the mast can be built up in multiples of 10 ft to a maximum height of 150 ft. The mast is stayed at 20- or 30-ft intervals, and stay-plates are provided at each corner of the upper end of each unit. This light welded structure is of triangular section, each face of the triangle being 12 in. wide. As it is constructed chiefly of steel tubes, the mast itself weighs only 7 lb per foot of length. Climbing rungs are incorporated in one face.



The units are constructed of mild steel, and each consists of three tubular corner posts, braced together by rods. The assembly is welded together in a rotary jig. After fabrication, the mast units are hot-dip galvanized and, as the tubes are coated both inside and outside, efficient protection is given against corrosion. As erection progresses, additional units are added, using two $\frac{1}{2}$-in. bolts at each corner joint. All bolts and other accessories are galvanized. Erection can be accomplished with the minimum of labour, the mast being built up, section by section, in the vertical, using a light-alloy derrick pole, as shown in the illustration. These poles, together with the necessary fittings, are supplied as an extra item. A 150-ft mast will withstand a head load of 1000 lb plus a wind of 100 mph.

Standard Fume Ducts in Plastic

The tremendous advantage offered by the use of plastics is that, unlike the metal ducts used hitherto they are in no way susceptible to corrosion. Another important feature of such plastic ducting is that it can be quickly and easily erected by a factory's own maintenance staff, with a further saving in outlay. Fabricated by Rediweld Limited, of Crawley, Sussex, and marketed under the name of " Polynert ", a complete standard range of polythene and P.V.C. tubes and ducts is now available for the construction of duct lines for corrosive fumes.

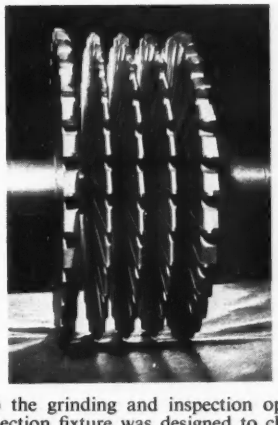
Standard sections in the " Polynert " range are available in 3-ft lengths, with dimensions graduated in 2-in. " steps " from 4 in. to 30 in. The various sections have all the appropriate flanges, elbows, T-pieces, backing rings, and joints necessary for fume-disposal systems. The thickness of the sheet stock is $\frac{3}{16}$ in. for pipes and fittings, whilst flanges are based on $\frac{1}{4}$-in. stock.

For simplification, Rediweld have evolved a novel set of paper cut-outs representing the various standard sections at a scale of 1 : 12. As a result, the designer has merely to lay the cut-outs on the plan view and elevations of the building concerned, enabling him to observe rapidly the results, without spending a great deal of time drawing in the system. Once a satisfactory layout is settled, the cut-outs can be secured to the drawings and passed to Rediweld for a quotation.

Large Milling Cutters for Aircraft Production

EXTREMELY large milling cutter gangs for the machining of high-tensile steel aircraft component parts are being supplied by English Steel Tool Corporation Ltd., of Manchester, to Vickers-Armstrongs (Aircraft) Ltd., Supermarine Works, Swindon. One of the gangs (illustrated) consists of two 15·200-in. diameter single-angle cutters and three 14·952-in. diameter double equal-angle cutters. Although they are not the largest cutters made by the Company, they are amongst the largest solid H.S.S. cutters of this type made in Great Britain.

The important features of the gang were the angle of taper, the width of the cutters, and the steps between the cutter diameters, all of which had to be controlled to exceedingly fine limits. In addition, the double equal-angle cutters were of a rather slender section, tapering from 1·050 in. wide to a tip radius of 0·18 in. In the design stage it was decided that, as the bulk of the material would be removed by the tip radius, it was necessary to provide at that point a positive cutting rake which, when continued down the sides of the cutter, would supply the side teeth with the necessary shearing action, the depth of the cut being approximately 6 in. Moreover, to give all the teeth a positive rake would have made an already awkward proposition extremely difficult, so that it was decided to have three equally spaced teeth radial, i.e., with no rake. This accounts for the uneven spacing and lengths of the teeth towards the centre of the cutter. On the shop-floor careful attention was paid to the turning and milling operations, and special gauges and tackle were used to keep the amount of material to be removed at the grinding operation to a minimum.



To help the grinding and inspection operations, a special inspection fixture was designed to check all the important elements of the cutters. Its principle was a master base, bushed to accept the cutters whilst still mounted on specially designed precision grinding arbors, and a sliding taper gauge which checked the angle of

The Bristol "Britannia" *(Photograph by permission of The Bristol Aeroplane Co. Ltd.)*

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taper. The cutter chordal widths were controlled by measuring with block gauges the distance between the end of the taper gauge and the arbor. The most difficult operation, however, was the grinding, as, not only had the cutters to be ground to size, but they had then to be sharpened to produce a cutting edge without reducing the dimension.

Radiant-Heat Boilers

Five boilers designed and manufactured by Clarke, Chapman & Co. Ltd., of Gateshead, have been commissioned and put on load at Stella North and Stella South Generating Stations, near Blaydon, Co. Durham, in the past year. Clarke Chapman have four more boilers to complete, and these will be operating by the end of this year.

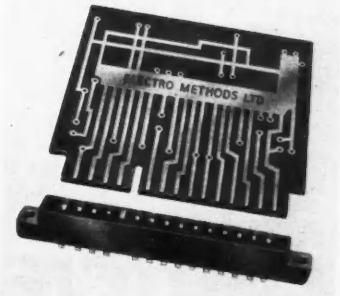
The boilers at Stella are of the radiant-heat type, each comprising a fully water-cooled combustion chamber with controlled-type superheater, and an economizer. Each boiler is fed by four Raymond bowl mills, which supply them with pulverized fuel. Auxiliary equipment includes air heaters, electrostatic precipitators, and mechanical draught plant. Each boiler has the following rating :—Evaporation, 550,000 lb/hr; steam pressure, 950 psi ; and steam temperature, 925°F.

Electrical Components

A licensing arrangement with Winchester Electronics Incorporated, U.S.A., to manufacture a complete range of high-grade electrical components, is announced by Electro Methods Ltd., of Stevenage, Herts. This range includes miniature and sub-miniature connectors, self-separating connectors, hermetically sealed connectors, printed-circuit connectors, and stand-off terminal insulators. Production is scheduled for early April, 1956, when a range of plugs and receptacles, printed-circuit connectors, and stand-off insulators will become available, as follows :—

The plugs and receptacles, series M.R.E., will be available in six ranges, from 7-pin to 50-pin. All mouldings will be of mineral-filled Melamine, giving excellent physical and electrical properties. Pin contacts will be of brass, while socket contacts will be of spring-temper phosphor bronze, both being precision-machined and gold-plated over silver, for low contact resistance and for prevention of corrosion and ease of soldering. Each contact will carry up to 7·5 A, and the d.c. breakdown voltage between pins, with connector engaged, will exceed 3700 V at sea level and 1050 V at 60,000 ft. With contacts to earth, these figures will be 3000 V and 950 V respectively. Both plugs and receptacles can be fitted with aluminium hoods and cable clamps which provide support and strain relief for cables.

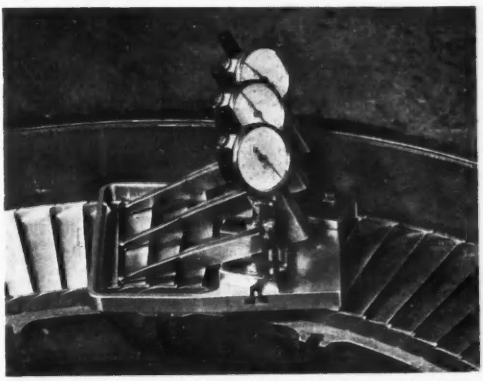
The printed-circuit connectors, series K, will have $\frac{1}{10}$-in. centre-to-centre contact spacing and 5-A contacts. They will be available in 6, 10, 12, 15, 18, and 22 contact-position receptacles, with contacts of spring-temper phosphor bronze, gold-plated over silver, and bodies of mineral-filled Melamine. Two types will be provided, the " S " type for solder-cup terminals and the " T " type for riveting receptacles to the circuits of a printed card. A typical printed-circuit connector is illustrated.



The stand-off terminal insulators will consist of a complete line of stand-off terminals designed to fill the need for a rugged, well-insulated tie-point or mounting block, for chassis and other wiring assemblies. These insulators will be moulded from asbestos-filled Melamine. The solder terminals will be of brass, hot tin-dipped for easy soldering. The d.c. breakdown voltage will be 13 kV.

Instrument for Checking the Throat Area of Diffuser Rings in Jet Engines

Recently developed by British Indicators Ltd., of St. Albans, Herts., a new instrument for checking the throat area of the diffuser rings fitted to jet turbine engines provides simultaneous readings at three points between adjacent blades.



Each measuring head is adjustable in three planes, to enable measurements to be taken at the precise positions required, while the heads are mounted on pivot bearings in such a way as to ensure the automatic entry of the heads into the throat-area gap. As a result, the whole instrument is merely slid forward on the datum provided by the tops of the blades during the measuring operation ; the minimum reading is taken as the instrument is withdrawn and the deviation from true size noted. Each measuring head operates independently, and any rocking which may take place as a result of unevenness of blade-edge surfaces does not affect the accurate reading of the instrument.

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CLASSIFIED ABSTRACTS

Numerous important abstracts which, for lack of space, cannot be published in our main editorial columns are regularly included in condensed form in this section. Subscribers may obtain photostat copies of all original articles at cost.

CORROSION

High-Temperature Hydrogen Sulphide Corrosion.
By E. B. BACKENSTO, R. D. DREW, and C. C. STAPLEFORD. (From *Corrosion, U.S.A.*, Vol. 12, No. 1, January 1956, pp. 22–32, 11 illustrations.)

IN recent years, hydrogenation and dehydrogenation processes for upgrading petroleum fractions have become commercial realities in the petroleum industry. These processes operate at high temperatures and hydrogen pressures and usually form hydrogen sulphide, which is corrosive under these operating conditions. It has been known for some time that, when hydrogen sulphide corrodes carbon and low-chromium steels, an iron sulphide corrosion scale is formed. The literature on the separate effects of hydrogen sulphide and hydrogen is voluminous. Limited information is, however, available on the combined effects of hydrogen-hydrogen sulphide, and these data are based on short-term tests, generally at higher pressures and hydrogen sulphide concentrations than are likely in the petroleum industry.

Hydrogenation plant experiences have served as a forewarning of the seriousness of this problem in catalytic reformers. Nelson defined the sulphide scaling problem and indicated the need for high-chromium alloys. On the other hand, however, considerable use had been made in the oil industry of low-chromium steels without difficulty in fractionation, catalytic and thermal cracking, and thermal reforming equipment. Therefore, when catalytic reformers were designed, economics appeared to favour low-chromium steel construction, since the seriousness of sulphide corrosion was not fully understood.

The effects of temperature, pressure, and hydrogen sulphide concentration on the corrosion rate of a wide range of commonly used carbon steels and alloys have been determined in laboratory tests. It has been established that the low-chromium alloys (up to 5% chromium) which have been used to combat sulphur corrosion in fractionation and cracking equipment, show little or no advantage over carbon steel in resisting attack by hydrogen sulphide. Of the conventional alloy steels tested, only the 18-8 Cr-Ni and higher alloys have shown good resistance to this type of corrosion over a wide range of pressure, temperature, and hydrogen sulphide concentration. It was found that aluminium-coated steels also showed very good corrosion resistance.

Three methods are proposed for minimizing hydrogen sulphide corrosion, i.e., (1) reduction of hydrogen sulphide in process streams ; (2) use of chrome-nickel alloys ; and (3) protection by aluminium-coating.

ELECTRONICS

An Accurate Electronic Multiplier.
By S. STERNBERG. (From *RCA Review, U.S.A.*, Vol. 16, No. 4, December 1955, pp. 618–634, 14 illustrations.)

ANALOGUE computers have, in the past, been limited with regard to speed, reliability, and accuracy by the multiplier component. Where accuracy was not a requirement, electronic multipliers have been built which were fast and reliable. However, accuracy could be obtained only with mechanical or electromechanical devices which were slow and subject to short-term wear. A high accuracy electronic multiplier using a time-division principle was first reported in 1952. The resulting equipment was a laboratory model which proved the basic time-division concepts and demonstrated an electronic switch with excellent characteristics. In the early part of 1953 work began on a dynamic systems synthesizer. Since the basic concept of the synthesizer was to build a machine without mechanical moving parts, a highly accurate electronic multiplier was required. It was decided to use the time-division principle and attempt to provide for long-term stable accuracy and increased speed of multiplication. This paper describes the results of the development work and the final multiplier design.

In a time-division multiplier a waveform is generated whose amplitude is proportional to one variable and whose time division is proportional to the other. The average value of the waveform represents the multiplication. The basic component of the multiplier is an electronic switch. This switch should be sufficiently accurate to ensure that the accuracy of the multiplication depends only on the combined stability of the wire-wound resistors used in the signal paths and the stability of power-supply voltages. The switch must operate at a sufficiently high frequency so that the computing signal frequencies are not affected by the required filtering operation.

The design incorporates a novel dynamic balancer for switch tubes, making it possible to obtain and maintain a static accuracy of 0·01% at a switching rate of 10 kc. The dynamic performance of the multiplier is specified by the gain-phase characteristics of a filter which is an integral part of any time division multiplier. A filter is described which maintains a very small phase shift at the computing frequencies and also eliminates the requirement for pulse-handling d.c. amplifiers. An accuracy of 0·02% in amplitude with a phase shift of 0·0016 mill.radian at 20 radians per second has been obtained. A small dynamic systems synthesizer has been constructed which contains eleven multiplier chassis. The performance of this multiplier in terms of combined accuracy and speed of response is better than any other known to the author.

FLOW MECHANICS

Supersonic Diffuser Instability.
By C. L. DAILEY. (From *Journal of the Aeronautical Sciences, U.S.A.*, Vol. 22, No. 11, November 1955, pp. 733-749, 19 illustrations.)

THERE are two principal requirements of a supersonic diffuser, i.e., it must decelerate the entering air mass sufficiently to allow steady combustion, and it must compress the air mass before heat addition to achieve good thermal efficiency. The former requirement is easily met, as it is a simple matter to reduce the velocity approaching the burner to an arbitrarily low value by appropriate subsonic diffusion. The only penalty is a corresponding reduction in thrust relative to the burner frontal area. This is offset by an increase in cycle efficiency, but the gain is so small that it is of no practical importance. In practice, every effort is made to achieve the maximum burner velocity compatible with good combustion efficiency and stable burner performance. Whatever may be this maximum, it simply becomes a design requirement for the diffuser, and this requirement can easily be met.

The second problem is more complicated. In order to compress supersonic flow it is necessary to reduce the area through which it passes. To achieve good overall efficiency it is essential to obtain the maximum possible supersonic compression. This is obtained with the least inlet contraction ratio which will allow starting.

This paper presents the results of an experimental

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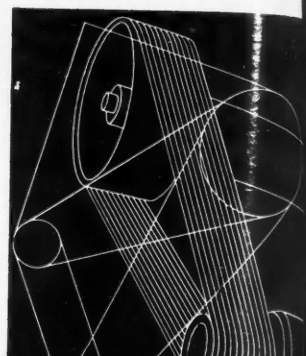

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determination of the nature and cause of an instability which has been found to be characteristic of supersonic air inlets operating near maximum mass flow. Steady operation is interrupted by a transient phenomenon consisting of a random sequence of individual relaxation cycles. Mass flow entering the diffuser during steady operation is suddenly cut off by a strong interaction between the subcritical shock and boundary layer on the surface of the external compression generator which blocks the inlet. Air in the plenum chamber, stored at high pressure, then " blows down " until the inlet can restart. The subsequent supercritical flow entering the diffuser exceeds the flow rate at the exit, and the plenum chamber is recharged to the original condition. A distinction is drawn between this phenomenon, referred to by the author as " buzz ", and a high-frequency wave-type resonance noticed at low mass flows and during an individual buzz cycle after the diffuser shock system has been expelled. For the diffuser described in this paper, this high-frequency oscillation compares well with the eighth closed-end organ-pipe mode of the diffuser at low mass flows and to the ninth mode during the shock-expelled phase of the buzz cycle. It was also found that buzz had a strong adverse effect on combustion stability. In most cases blow-out occurred immediately after the occurrence of the first buzz cycle. When burning was maintained during buzz, it was found to have no qualitative effect on the buzz cycle.

LUBRICATION

Roll-Neck Lubrication.

By H. C. INLOW. (From *Iron and Steel Engineer, U.S.A.*, Vol. 32, No. 11, November 1955, pp. 104-107, 6 illustrations.)

LUBRICANTS in steel mills must function under possibly a greater variety of adverse conditions than in any other industry. This paper deals mainly with the spray application of roll-neck grease and oil. This is the most recent advance in the lubrication of roll necks. General requirements for spray-application lubricants are that they be water-resistant, provide an adhesive film, possess extreme-pressure properties and be pumpable through a pressure system. The types of mills on which these lubricants find application include blooming, billet, slabbing, bar, and plate mills, while the types of roll-neck bearings usually encountered are fabric, bronze, babbitt, or combination and segmented. Plain roll-neck bearings usually operate under conditions of high pressure, shock loading, and exposure to bad water. Thus, in order to lubricate these bearings properly, the lubricant must adhere well to the roll necks and resist being washed off by water.

In installations where the spray application of the roll-neck lubricant has been used, it has proved to be of considerable merit. Spray application does not provide all the answers to the ideal lubrication of roll necks but it has proved itself worthy of extensive consideration, arising from very conclusive results of improvement in certain locations. In one outstanding example, bearing life was increased some five times. From this it is obvious that considerably increased tonnage was realized per bearing change. More recent field trials have shown that bearing life and tonnage are increased even more when roll-neck spray oil is used instead of the roll-neck grease. Actual tonnage figures are, however, not available. With proper combination of lubricant, spray nozzle, and pump timing, the system is the best method known to date for lubricating the open-type babbitt bearing.

Additional advantages from the use of these roll-neck lubricants have also been noted. The number of lubricants required for mill operation can be reduced in that the roll-neck lubricants can also be used for other purposes. Roll-neck grease can be utilized for screw-down screws and nuts, housing windows, table bearings, and spindle carrier bearings. Roll-neck spray oil can also be used for pinion-stand lubrication and for enclosed vertical gear sets.

PUMPS

Water-Ring Self-Priming Pumps.

By E. CREWDSON. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, January 13, 1956, 13 pages, 16 illustrations.)

ALTHOUGH water-ring self-priming pumps have been in common use for over 25 years, their general method of operation is unfamiliar to many engineers, and indeed there is a considerable difference of opinion as to the precise mechanism by which they produce their pumping effect.

In this paper, the method of operation of water-ring self-priming pumps is briefly described, with performance data of three designs of such pump. The mechanism by which these pumps produce their effect is discussed, and the conclusions reached indicate that it is impossible to anticipate their performance from their physical dimensions, as can be done with a centrifugal pump. If, however, the head-discharge curve of any pump is established, and the horse-power required to overcome mechanical and disc friction is known or can be closely estimated, the horse-power taken by the pump at any point of its range can be calculated with a high degree of accuracy. Amongst the information included are graphs of air-pumping capacity and details of experiments to determine the best designs of rotor vane. Small changes in the shape of the vanes produce remarkable differences in performance.

The water-ring self-priming pump has a useful field where relatively small quantities of water are to be delivered against relatively high heads. For pumping volatile or hot fluids it is ideal, as it cannot become vapour-locked. It may be conveniently incorporated with a centrifugal pump to make the latter self-priming. Its specific speed is very low compared with any ordinary centrifugal pump, and for that reason it can provide high heads at modest speeds of revolution. Its efficiency compares reasonably with that of a centrifugal pump of very low specific speed, but cannot approach that of a large pump of high specific speed. Moreover, in large sizes it runs at an inconveniently slow speed. It will pump satisfactorily with 28 ft of suction lift at sea-level, but its capacity in gallons per minute is then substantially reduced (up to 30% or more) compared with pumping against the same total head with only 10 or 15 ft of suction lift.

THERMODYNAMICS

The Use of Sodium and Sodium-Potassium Alloy as a Heat-Transfer Medium.

By W. B. HALL and T. I. M. CROFTS. (From a paper presented at a meeting of *The Institution of Mechanical Engineers, London*, January 18, 1956, 12 pages, 11 illustrations.)

THE advent of the nuclear reactor as a heat source, with its almost unlimited potential heat rating, has stimulated the search for a heat-transfer medium capable of operating over a wide temperature range with a good heat-transfer coefficient. As a consequence, the use of liquid metals for this purpose has received much attention during the past few years. In the design of a reactor cooling circuit, many limitations are imposed by nuclear physics, and it is not necessarily the case that a good reactor coolant is also the best choice for an industrial heat-transfer process. It appears, however, that sodium and sodium–potassium alloy are suitable for general application to heat-transfer problems where high heat fluxes and temperatures are concerned.

For industrial application, the wide temperature range over which many liquid metals can be used is likely to be at least as attractive as the high heat-transfer coefficients which are obtained. In contrast with the nuclear reactor, it may be neither necessary nor desirable to operate at heat fluxes which are as much as ten times those in a modern water-tube boiler; much of the apparent advantages of so doing is lost in excessive temperature drops through walls of pipes.

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At the outset of the work described in this paper the choice of liquid metal seemed to be between mercury, sodium, and sodium–potassium alloy, and the various lead–bismuth or lead–bismuth–tin alloys. It was clear from the literature on the subject that sodium or sodium–potassium had an advantage over mercury and lead–bismuth, as far as corrosion of steel was concerned; it is also cheaper, and it has a much more useful working temperature range than mercury. Mercury has the further disadvantage that its vapour is highly toxic. The main disadvantages of the alkali metal lie in the prevention of oxidation either inside the apparatus where the oxide may block the pipes, or outside where it may cause a fire; there is also the reaction with water, which may in certain circumstances cause an explosion. In spite of these disadvantages it was decided that the work should be concentrated upon sodium and sodium–potassium alloy.

After discussing the applications of liquid metals in heat-transfer problems, comparing those metals whose melting points are sufficiently low to make them of interest in this respect, a number of sodium and sodium-potassium circuits which have been built and operated over the past three years are described; some of these were built in order to gain experience in handling the liquid metals, whilst others were for heat-transfer experiments. A general discussion on the design and construction of liquid-metal circuits and the components which are commonly used in them is given, together with a brief discussion of forced-convection heat transfer with liquid metals, and the results of some work on cavitation in sodium-potassium eutectic flowing through a constriction in a pipe.

TRANSFORMERS

Models for the Experimental Analysis of Surge Phenomena in Transformers.

By A. VEVERKA. (From *Elektrotechnicky Obzor, Czechoslovakia*, Vol. 44, No. 7, 1955, pp. 383-384).

THE mathematical analysis of transformer surge phenomena is very involved when various details of design are taken into account. In such cases it is desirable to develop simple and sufficiently accurate methods for the investigation of surge phenomena, and models offer good possibilities for this purpose.

Dimensional laws for transformer-winding models are derived from known theories of similarity. Oscillations in the model should reproduce those occurring in the original, and this is, in fact, the case when the following two conditions are fulfilled :—

(a) The model and original are geometrically similar, and the number of windings is equal. The resistivity of the model winding conductors is decreased according to the geometrical ratio of original to model. Experiments indicate, however, that resistance only slightly influences the transient processes.

(b) Time values determined on models with the aid of oscillograms must be multiplied by the linear ratio of the original to the model.

Geometrically similar models have not often been used, owing to the following disadvantages :—

(1) The necessity for a considerably decreased time scale for the phenomena on the model introduces surge waves of very short duration. It is often impossible to simulate with the model the wave-front steepnesses occurring in the original.

(2) It is not possible to simulate the non-linear properties of iron.

(3) The construction of geometrically similar models with accurately similar electrical and magnetic fields is often difficult.

(4) The laborious transfer of jointly distributed self- and mutual inductances from original to model excludes the possibility of using equivalent circuits with appropriate inductors, capacitors, and resistors.

The disadvantages of the geometrical and equivalent circuit can be obviated with the aid of a combined electromagnetic model. This consists of a geometrical model of the electromagnetic part of the transformer and of an equivalent capacitive circuit connected to it. The geometrical model of the electromagnetic part includes the self- and mutual inductances, and the capacitative circuit simulates the dielectric part of the transformer. The voltage applied to the combined model is such that the degrees of saturation in corresponding parts of original and model are equal. The influence of frequency on the model parameters must be eliminated as far as possible, and the arrangement is chosen so that the ratio of decrease of surge duration does not differ much from unity.

Relations for the electromagnetic model have been derived. The analysis is based on the most general form of the differential equation of transient phenomena of a single-layer cylindrical coil, taking into account the self- and mutual inductances of the turns.

Three corresponding parameters in original and model can be chosen independently. The choice aims at a model of suitable design, which is tested at comparatively low voltages. The capacitors are chosen large, so that the capacitances in the model can be neglected against the capacitances of the additive circuit.

WELDING

Crack-Arresting by Overlays of Notch-Tough Weld Metal.

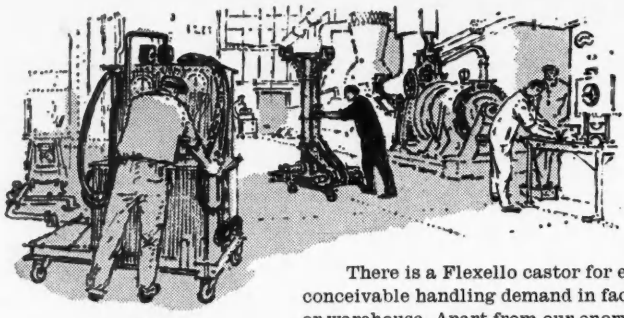
By P. P. PUZAK and W. S. PELLINI. (From *The Welding Journal, U.S.A.*, Vol. 34, No. 12, December 1955, pp. 577s–581s, 9 illustrations.)

EXPLOSION-LOADED, crack-starter tests of mild-steel ship plate have demonstrated that the relative resistance of the steel to the propagation of brittle fracture is related to the development of surface shear (shear lip). At test temperatures such that the mild-steel plates shatter completely, the unaided eye cannot discern evidence of surface shear, though extremely tiny fins, however, are present. At higher temperatures, such that the plates resist fracture to the extent of limiting the cracks to the plastically deformed bulge regions, easily visible shear lips of 0·020 to 0·050 in. thickness are developed. The amount of shear lip increases rapidly at still higher temperatures to the point of developing complete shear across the section, and completely ductile behaviour is exhibited by the steel.

The development of surface shear in lip form results from the fact that free surfaces approach a condition of stress biaxiality compared with the stress triaxiality which may be developed in the inner regions of thick plates. Thus, if the steel is tested over a range of temperatures involving a transition from complete brittleness (fracture surface entirely cleavage) to complete ductility (fracture surface entirely shear), the first portion of the fracture face to show ductile behaviour is naturally the free surface region of lowest stress triaxiality. The important point is that a relatively minor thickness of surface shear lip imparts a large measure of resistance to the propagation of high-velocity brittle fractures.

This paper describes crack-starter explosion tests which were utilized to demonstrate the feasibility of using overlays of notch-tough welds to prevent the initiation and propagation of brittle fracture in otherwise brittle structural mild steels. Simple bead-on-plate welds of notch-tough weld metal were deposited on the surfaces of a mild-steel plate. Whereas fragmentation of the prime plate was obtained in crack-starter tests at 20 and 40°F, similar tests of plates featuring overlays of notch-tough weld metal demonstrated that brittle fractures do not propagate in overlay regions.

It is recommended that notch-tough weld deposits be considered for the protection of welded structures by application at points where brittle fractures are known to initiate, i.e., points of connections or discontinuities. The method is considered practical for application to existing or new structures.



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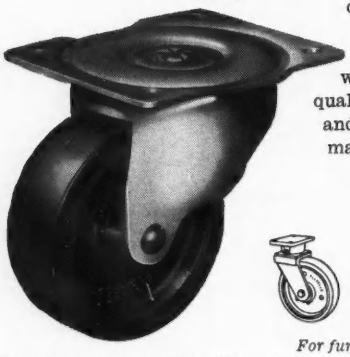

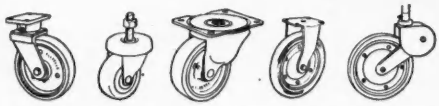

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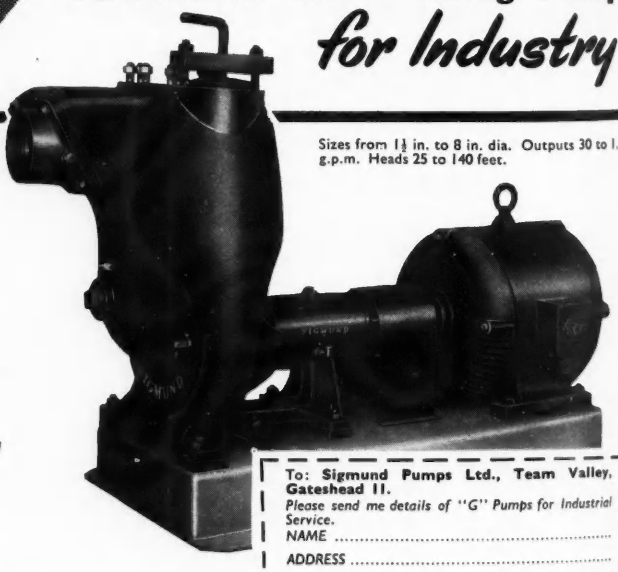

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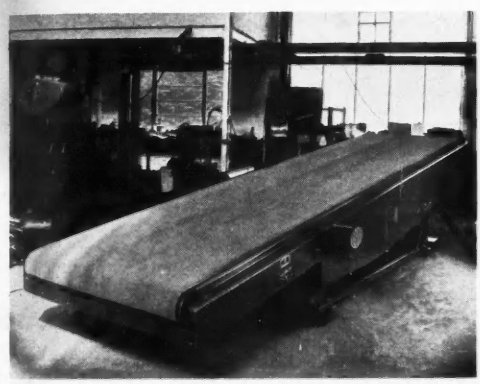
UNIVERSAL PORTABLE CONVEYOR

A new type of belt conveyor, with many interesting features, has been produced by the Clarke Ellard Engineering Co., Ltd., of Letchworth, Herts. The conveyor illustrated has been specially designed for conveying motor-car body-panel pressings from press to press during the various stages of manufacture. Generally, the conveyors manufactured for this specific purpose vary in width from 3 to 5 ft and in length from 12 to 25 ft. The height of both the receiving and delivery ends of the conveyor can be adjusted to suit the requirements of the different-size presses. For example, it can be adjusted to be 25 in. high in its lowest horizontal position, or up to 40 in. high in its highest horizontal position. Alternatively, to suit conditions where the presses are not of uniform size, the conveyor can be tilted from 18 in. to 48 in. at either end. Tilting is effected by an entirely new mechanism, consisting of simple gearing and levers operated by a winding handle at either end.



All conveyors are designed for a load of 50 lb/sq ft and operated at a speed of 50 fpm. Special guiding arrangements are fitted at either side and at both ends of the conveyor to prevent the wide belts from tracking. Other salient points of design are that an automatic belt-tensioning device is fitted, and the conveyor can be operated from both sides by special push-buttons. Special lugs are incorporated for lifting the conveyor with an overhead crane. Manoeuvrability is facilitated by the use of ball-bearing swivel castors, and the conveyor can easily be locked into position by the use of simple hand-operated stabilizing screw jacks. Finally, no parts of the conveyor protrude beyond the width of the belt, thus obviating damage to irregularly shaped components being conveyed.

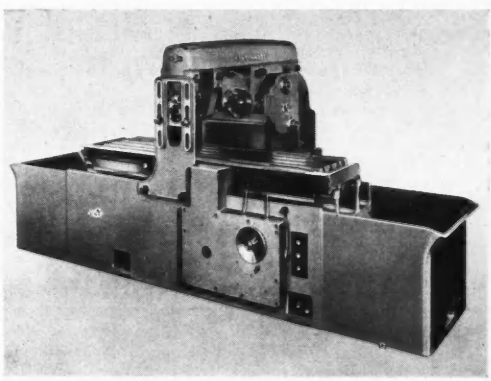
HEAVY-DUTY MILLING MACHINES

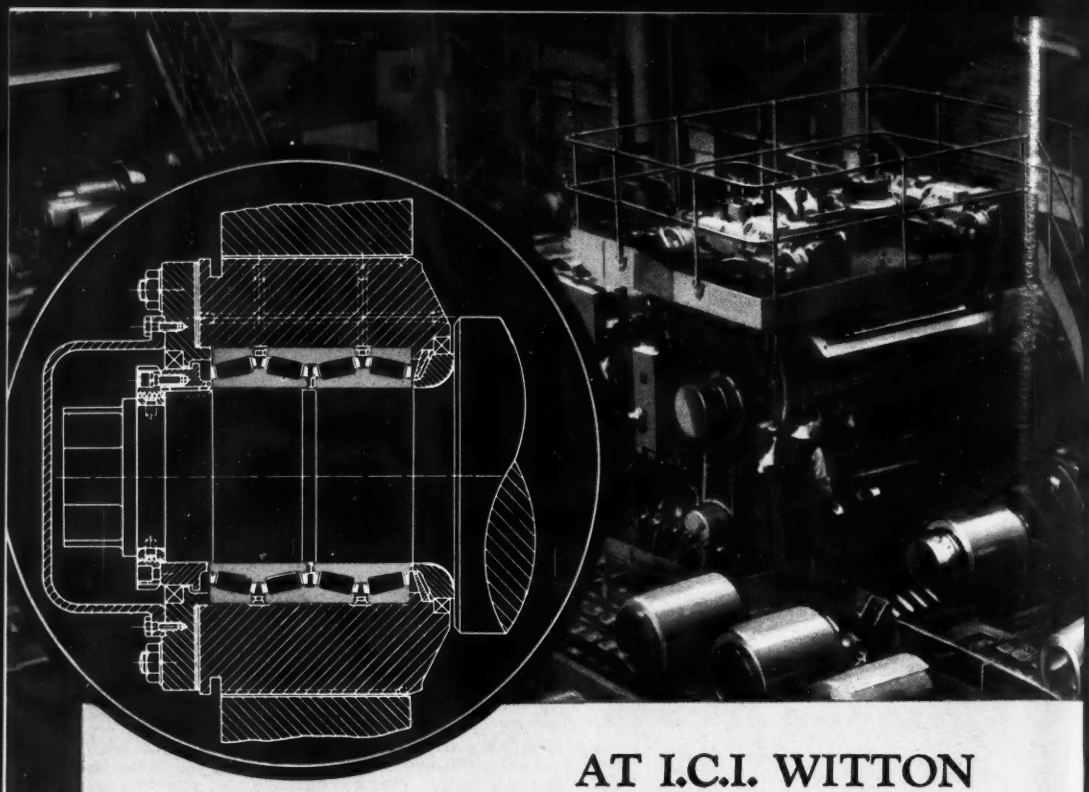
A new line of heavy-duty bed-type milling machines has recently been developed by Cincinnati Milling Machines Ltd., of Birmingham. These machines, designated "HyPowermatic" are equipped with automatic two-way feed cycles and infinitely variable feed rates, and are designed for continuous operation on medium to larger size parts. Much heavier and more powerful than the models they supersede, they offer increased cutting capacity (up to 50 hp) and higher spindle speeds (up to 2000 rpm) for taking conventional milling or climb-milling cuts, with either high-speed steel or sintered carbide milling cutters. Standard machines in the range are built in plain and duplex styles in forty-two sizes of each type, from 36-in. table travel, 7½ hp, to 168-in. table travel, up to 50 hp.

The bed-ways are extremely long and square-gibbed for accuracy and rigidity. Intermittent, dog-controlled automatic table cycles are provided. Feed rates may be infinitely varied throughout their complete range of ½ ipm to 100 or 150 ipm, depending upon machine size, by means of an easily operated feed-rate selector dial. The table is driven by a new "Hydramech" type of unit, enclosed within the bed, where it is protected from dust and grit. It consists primarily of a hydraulic motor, with an infinitely variable arrangement, driving a worm and dual worm, which in turn drives twin vertical pinions engaging the table rack. Anti-friction bearings throughout and an automatic pressure lubrication system ensure long life and trouble-free service. The multiple advantages of conventional milling or climb milling are made available through a built-in backlash-eliminating device.

Operating controls are conveniently and compactly grouped on the front right-hand side of the bed at the operator's normal working position. Quick positive starting and stopping of spindle rotation is obtained through two hydraulically operated multiple-disc clutches, both of which are actuated from the spindle start-stop lever at the operator's station. Also included in the control group are the four-position directional control lever to provide engagement of the table feed, and rapid traverse (right and left), the table stop, and automatic spindle stop levers. Sixteen spindle speeds can be obtained through change gears and a back gear combination. A choice of nine ranges of spindle speeds is available. Power to the spindle is by direct drive transmitted through short, heavily proportioned shafts mounted on anti-friction bearings. The heavy spindle with the bull-gear straddle mounted between the two rear anti-friction bearings provides the flywheel effect desirable in high-speed carbide milling. Vertical adjustment of the spindle carrier is over wide square-gibbed ways on the headstock. A built-in hydraulic counterbalance facilitates raising and lowering of the carrier. Quill construction provides the means for obtaining cross-adjustment of the spindle and cutter. An exclusive feature is incorporated for damping self-excited chatter and smoothing out the cutting, thereby permitting higher feed rates to be used and the use of heavier cuts up to the full power of the machine.

Lubrication of the principal units of these machines is completely automatic. The table ways and the drive mechanism are lubricated by a power-driven pump from





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The illustration shows two 6½"/8½" and 28", by 32", 4-high mills, for rolling copper and brass strip at speeds up to 1,000 ft. per min.

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The line drawing shows the 4-row balanced-proportion bearings, as used on the back-up rolls.

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a self-contained reservoir within the bed. Spindle bearings, gears, and other parts within the carrier are automatically pressure-lubricated, while the arbor bearing collars have gravity lubrication from a reservoir in the arbor support.

Electrical controls and push-buttons are built-in, protected against damage, dust, and moisture, while numerous electrical safety features are incorporated. Coolant equipment incorporates a three-way switch, offering the operator a selection of continuous flow or automatically " on " and " of " with the starting and stopping of the spindle rotation. The chip wipers attached to the underneath side of the table are designed to push accumulated chips from the troughs adjacent to the table to the large chip compartments at each end of the bed, where they may be removed without interrupting machine operation.

CENTRIFUGE FOR TESTING AIRCRAFT COMPONENTS

A new centrifuge which will simulate the flight of a rocket and which permits the simultaneous testing of two 1-lb specimens up to 300 *g* or two 10-lb specimens up to 100 *g*, is announced by the Hycon Mfg. Company, of Pasadena, California. The unit, designed primarily for production testing in the aircraft industry, reaches peak velocity in less than 1/7th of a second, and, operating with a magnetic clutch and magnetic brake on a split shaft, can simulate virtually any rocket-launching acceleration by varying the amount of electrical current in the clutch and brake.

A constant check on the accuracy of this centrifuge, designated " Vari-G ", is maintained by the installation of a strain gauge on the rotating arm just inboard of the test cavity. Information from this gauge is transmitted to the control console, where an oscilloscope and camera record the data, including both acceleration and deceleration, while easily changed programming cams simulate almost any time and acceleration problems. The unit has a 36-in., 500-lb flywheel driven by a 5-hp motor, delivering up to 55,000 foot-pounds of energy. The standard version includes 18 contact points (slip-rings) to record data, and requires less than 25¼ sq ft of floor space for both the centrifuge and the control console. No special electrical power source is required.

FUME-SCRUBBING AND ABSORPTION TOWER

A fume-scrubbing and absorption tower, claimed to be 100% efficient in the scrubbing of air saturated with sulphuric and hydrochloric acid, and 99·9% efficient with nitric acid, has been produced by Turner and Brown Limited, of Bolton. Designated " Turbro ", the tower has been specially designed for the elimination of sulphuric, hydrochloric, or nitric acid fumes discharged in considerable quantities from various chemical and industrial processes. For this reason, the tower and internal components are constructed entirely of rigid vinyl acetate. The standard unit is capable of scrubbing fumes from 14 to 20 litres of evaporated acid per hour, but larger towers are in course of construction for many varied fume-scrubbing requirements. The tower can be supplied with a special fume cabinet, or alternatively as a single unit for incorporation into existing equipment.

Complete removal of the gases is carried out in three stages, the first of which is by absorption of the greater part of the gases in the liquid; next, suspended globules of moisture are eliminated in a special eliminator section, and, finally, any small traces of gases left after these two processes are completely neutralized by a chemical reagent contained in a tray. The chemical-reagent tray is easily removed from the tower for recharging ; this is necessary every 10 to 14 days, depending upon the amount of fumes being scrubbed.

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Specially designed to assist in the physical interpretation of the Foundry Factory Act, a factory-floor sweeper has been specially evolved by the Bivac Air Company Ltd., of Portwood, Stockport, in which cleaning takes place by using a wide, cast floor-nozzle with extension tubes coupled to either end of the cleaner. Cleaning is rapid, positive, and dust-free, while special extension tubes and hoses are available for wall cleaning and for overhead dust removal.

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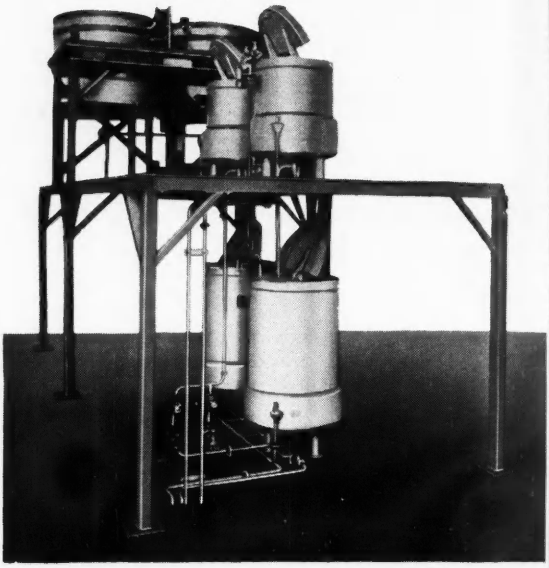

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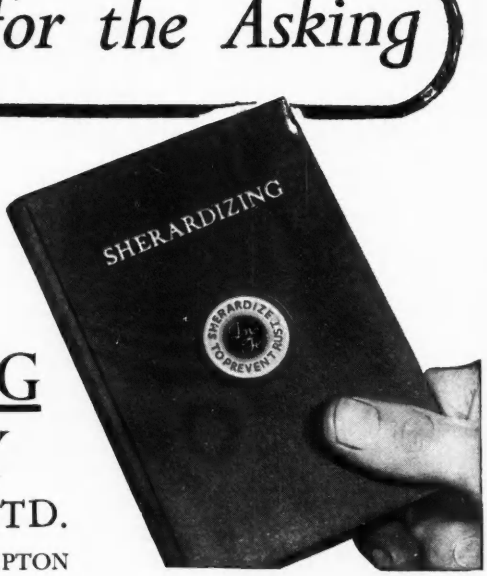

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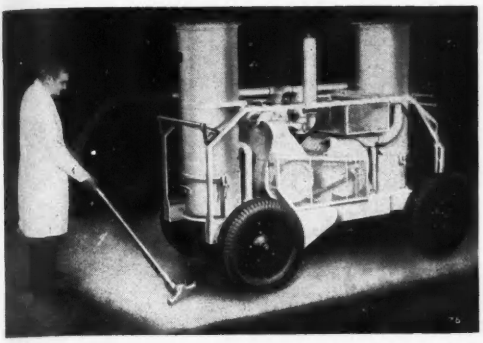
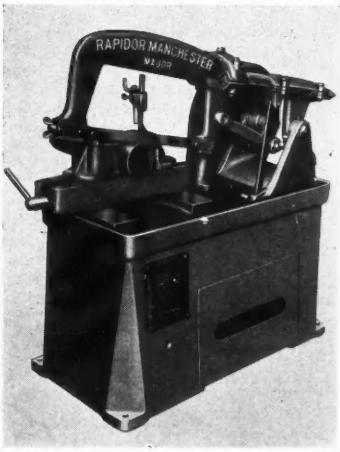


provided, control being through an extended handle with a sensitive hand-controlled cable-operated clutch, moving the complete unit at 2 mph. Obstructions on the floor are easily surmounted, and a " push-pull " brake is fitted for parking. Power is derived from an air-cooled 10-hp diesel engine. A V-rope drive transmits power from the engine to the exhauster, which is of the multi-stage turbo-type and which requires only occasional greasing of the bearings. When picking up foundry sand, a powerful suction is necessary for rapid removal, and adequate air displacement has been provided for this purpose.

MEDIUM METAL-CUTTING HACKSAWING MACHINE

The " Rapidor-Manchester " Major metal-cutting hacksawing machine, manufactured by Edward G. Herbert Ltd., of Manchester, is an improved version of their light-duty saw. Several new features have been incorporated and include a substantial cast-iron box base, in which is housed the drive mechanism, a heavier saw frame of rigid construction guided by two square steel bars to maintain perfect alignment and capable of taking 14-in. high-speed steel blades, an improved adjustable oil dashpot to give automatic relief to the saw blade on the return stroke, and a 6 × 6-in. capacity swivel vice. An electrically operated automatic limit switch, to stop the machine at the finish of each cut, and a two-speed drive arrangement, giving speeds of 120 and 65 strokes per minute, are supplied as standard equipment. Power is supplied through V-belts by an 0·5-hp motor controlled by a push-button-operated starter with undervoltage and overload release protection, the whole drive mechanism being totally enclosed. The suds pump, mounted in the box base, is supplied as extra equipment, and is of the gear type, driven by chain and sprocket from the motor-drive spindle.



The machine has been designed to incorporate a patent split vice, which can be supplied as an extra in lieu of, or in addition to, the standard swivel vice, as required. The design of this vice permits the saw blade to reciprocate through steel-lined slots in the centre of both jaws, so that both the blank to be sawn off and the bar or stock are held rigidly throughout the cut. With this vice it is therefore possible to cut short lengths of material which could not otherwise be sawn in the vice of an ordinary hacksawing machine, owing to the blade being off-set from the edge of the vice.

PROFILE PROJECTOR

Designed to project magnified profiles of small parts, screw forms, etc., onto a screen forming an integral part of the instrument, the new " Enbeeco " profile projector Mark III manufactured by Newbold & Bulford Ltd., of London, W.C.1, employs a 5 × 4 in. stage at right angles to the optical axis of the projection lenses, the image being projected onto the screen via suitable surface-aluminized mirrors with a quartz-hardened coating to permit cleaning without fear of damage. The stage can be operated in both lateral and longitudinal directions by means of micrometer movements, giving direct readings to 0·001 in. With a magnification of ×10, the maximum height of the work above the stage is 1¾ in., and with ×15, 1½ in.

The projection lenses (×10 and ×15) are mounted in a slide, so that the removal of one lens and the insertion of another is obviated. These lenses give excellent definition, good colour correction, and freedom from distortion. Objects up to ¾ in. in diameter are covered by the ×10 objective, and up to ⅜ in. diameter by the ×15 objective. Accurate projection of profiles is ensured by a specially computed condensing system providing illumination of the object by parallel light. Illumination is by means of a 100-W prefocused projection-type lamp, operated directly from a.c. or d.c. mains supplies. The screen, which has an aperture of 8 × 7¾ in., takes the form of two sheets of glass, between which a sheet of plastic tracing film is sandwiched. This not only obviates any necessity for frosting the screen, but also permits an enlarged drawing of the profile to be made directly on the tracing film, so that the projector can be used as a comparator.

serving the steel industry...

John Thompson Water Tube Boilers at THE STEEL COMPANY OF WALES LIMITED

John Thompson Water Tube Boilers supplied recently to The Steel Company of Wales Ltd. comprise:

Abbey Works, Port Talbot

Three Boilers: each 38,500 lb. per hour evaporation (summer) or 25,700 lb. per hour steam plus 13,000,000 BTU hot water (winter); 200 psig; steam temperature 590°F. Fired by blast furnace gas and/or coke.

Three Boilers: each 10,000 lb. per hour evaporation at 175 psig with steam at 440°F; fired by waste gases from slab re-heating furnaces.

Two Boilers: each 34,400 lb. per hour evaporation at 200 psig with steam at 600°F; fired by waste gases from melting shop furnaces.

Velindre Works, Swansea

Three Boilers: each 40,000 lb. per hour evaporation at 475/505 psig with steam at 670°F; fired by John Thompson Compartmental Type Stokers.

2,500,000 lb. of Steam per hour.
Steelworks in this country now generate 2,500,000 lb. of steam per hour from John Thompson Boilers.

JOHN THOMPSON WATER TUBE BOILERS LIMITED · JOHN THOMPSON GROUP

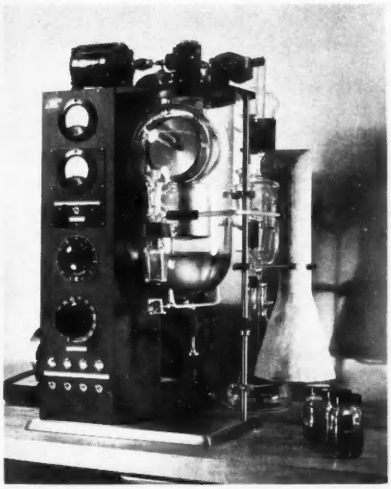
JOHN THOMPSON WATER TUBE BOILERS LTD
WOLVERHAMPTON

WT/103

CENTRIFUGAL MOLECULAR STILL

A laboratory-type centrifugal molecular still, providing a means of separating heat-sensitive materials of high molecular weights, is announced by the Consolidated Vacuum Division of Consolidated Electrodynamics Corporation, of Pasadena, California. Any non-corrosive material capable of being liquefied without molecular change and with a molecular weight between 250 and 1200 can easily be separated in the new still, which, by utilizing centrifugal action under high-vacuum conditions, ensures a lower thermal hazard to the distilland than any other accepted distillation technique.

Operating in the pressure range between 1 and 10 microns Hg, distillands are evaporated almost instantly, and samples of 0·1 to 1·5 litres capacity can be processed at a rate of 0·03 to 10 grams of distillate per minute. Significant features of the new still, designated CMS-5, include a choice of four feed rates, a maximum film thickness of 0·1 mm on the evaporating surface, continuous temperature measurement of the evaporation area, and contact of the distilland with the heated rotor for from 0·05 to 0·2 sec.



Industrial applications of this compact instrument, which requires a table-top area of only 18 × 24 in. and a minimum head room of 3 ft, include the distillation of many synthetic and natural oils, resins, perfumes, plasticizers, fatty acids, drugs, and oil-soluble vitamins.

SPECTROGRAPH SOURCE-EXCITATION UNIT

A new spectrograph source-excitation unit—a simplified power source for spectrographs used in industrial and educational laboratories—is announced by the Bausch & Lomb Optical Co., of Rochester, N.Y. The unit provides a.c. and d.c. arc power, together with a high-voltage spark for burning spectrograph samples of all kinds. Any of the three types of output may be obtained quickly by rotation of a selector switch on the control panel, and, because the source unit is built as a table, most spectrographs can be placed directly on it.

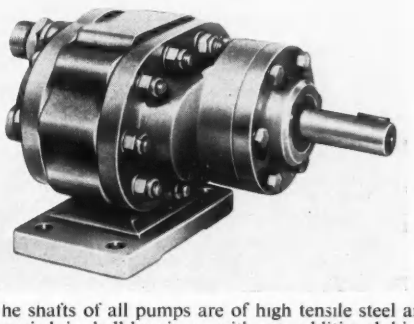
The d.c. arc is supplied by a 6-kVA transformer with a no-load potential of 240 V and a full-load current of 25 A. The a.c. arc is supplied by an 8-kVA transformer with a no-load potential of 300 V and a full-load current of 2·7 A. Both are controlled by a variable reactor, combined with a 21,000-V spark generator.

Features of the control panel include a circuit-breaker main switch controlling all power except for a convenience outlet ; a phasing control which regulates discharge

breaks ; an oscilloscope ; signal lights to indicate when the main power switch is on and which type of poser output has been set up by the selector switch ; separate meters for indicating current from each type of source unit ; a convenience outlet for supplying power to accessories or an inspection lamp ; and a receptacle for the external interlock system and spectrograph shutter. The source unit, which is 69 × 36 × 36 in. and weighs 1000 lb, has a sloping panel board, so that the controls are easy to reach and the meters easy to read. Safety factors include proper spacing and grounding of components, cut-out switches on doors, and connections for the interlock circuit to the spectrograph and electrode holders.

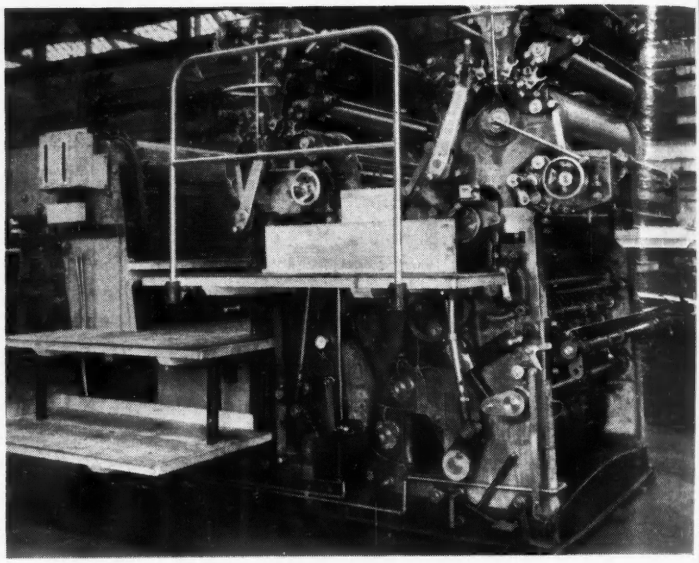
HIGH-PRESSURE HYDRAULIC GEAR PUMPS

A new range of high-pressure hydraulic gear pumps, designated " Norga ", has been introduced by George Angus & Co. Ltd., of Newcastle upon Tyne. These pumps are available in seven different sizes, providing a delivery range, at 1000 rpm, of from 2 to 16 gpm. Each size of pump is available in three basic types, i.e., horizontal foot-mounting (illustrated), vertical foot-mounting, and flange-mounting. The flange-mounting unit can also be obtained complete with power-take-off unit and control lever, for attaching to the majority of commercial-vehicle gearboxes, or, alternatively, in a compact motorized form, directly mounted to an electric motor.



The shafts of all pumps are of high tensile steel and are carried in ball bearings, with an additional high-capacity bearing on the input shaft. Another feature of the pumps is the provision of special, renewable wear-plates of high-grade phosphor bronze. These plates are quickly and easily replaceable, facilitating subsequent servicing.

Suitable for operating at pressures up to 1500 psi, these pumps will deal successfully with various fluids of widely differing viscosities.



'TECALEMIT-BIJUR' PUMP fitted on a rotary offset printing press made by Geo. Mann & Co. Ltd., Leeds.

Metered oil feed keeps the job clean — and the costs down

In branches of industry where the product must be kept scrupulously clean—such as Food, Fine Textiles or Printing—the problem is to avoid over-lubrication without risking under-lubrication.

Metered oil feed is the answer; and that is the principle of the 'Tecalemit-Bijur,' an automatic or hand operated system that provides intermittent lubrication. It consists of a lubricator unit and meter valves. The pump unit measures the total quantity of oil to be used in each cycle, and delivers it under pressure to the distribution system. The pipe line is branched to the various lubrication points where there are metering valves of known relative flow calibration. These feed the correct volume of lubricant to each bearing surface.

So oil starvation is avoided, while there is no excess lubricant present to contaminate the product or workshop floors. Output is boosted by reducing breakdowns to a minimum, while economy in lubricant cuts production costs.

It's easy for the machinery builder to offer his customers these important savings because Tecalemit's engineering staff will develop for him, without charge, complete designs for built-in centralised lubrication of his machines.

The ' Bijur ' is one of the wide range of Tecalemit lubrication systems for oil or grease used throughout industry.

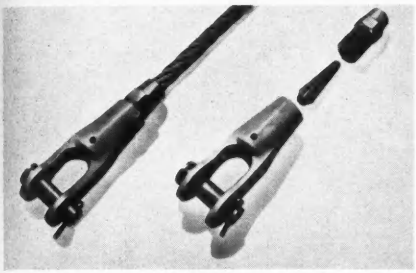
A Tecalemit technical representative will gladly supply full information on the ' Bijur ' system and its installation.

TECALEMIT
The Authority on Lubrication
PLYMOUTH, ENGLAND

WIRE-ROPE TERMINALS

Designed as attachments to wire ropes of any known specification, "Tulcon" wire-rope terminals, manufactured by Tulloch Construction Company Limited, of Sutton, Surrey, consist of compact assemblies of three simple units which, when assembled, form a terminal locking the wire rope to the assembly and making a connection which cannot come apart.

The assembly comprises a sleeve, to accommodate a given size and diameter of wire rope ; a plug, which is inserted to separate and hold the strands of the rope ; and a terminal, which can be made to suit any given application. The sleeve and the terminal are of forged alloy steel, while the plug is of shell-cast gunmetal. As a result, the complete assembly provides a strong terminal designed to exceed the strength of the rope to which it is attached.



Advantages of the "Tulcon" system are that unskilled labour can be used with simple tools, that the terminals can be attached within minutes, and that they are initially inexpensive. Furthermore, no heating, welding, or brazing is required. Plug inserts are provided for different types of wire ropes, and the lay of the wire is not affected or distorted in any way.

LOW-FREQUENCY WAVE-FORM GENERATOR

What is believed to be the most flexible source of test signals yet available for servo-mechanisms and electrical controllers in general has been developed by Servomex Controls Ltd., of Jarvis Brook, Sussex. The new instrument covers a very wide range of frequencies and amplitudes, and even the d.c. level of the output signal is also variable. No less than 18 different wave-forms are available.

The four main categories of wave-forms are square waves, triangular waves, sawtooth waves, and pulses. However, by means of a special selector switch, each type of wave can be used in three ways, i.e., continuous repetition ; single-sweep, either from the positive limit to the negative limit, or *vice versa* ; and double-sweep, or one complete cycle. Square waves with a pulse time of 1 millisecond will test systems with a band-width extending up to several thousand cycles per second. At the other extreme, it is possible to generate a single isolated ramp function lasting for 1000 sec, i.e., slow enough to test the majority of process controllers. The range of times from 0·001 to 1000 sec is covered in 6 decades. Each range of 10 to 1 is divided into 100 equal steps by means of two decade dials. The absolute accuracy is $\pm$ 2% of the indication but, by the decade switching, the incremental accuracy and the resetting accuracy are much higher.

The peak-to-peak output voltage swing is divided into six ranges, between 0 to 1·5 mV up to 0 to 150 V. Each range is available on a calibrated dial on a continuous potentiometer, the absolute accuracy being $\pm$ 3% of full scale on each range. A particular feature of the instrument is the method of controlling the amplitude, causing the upper and lower limits of the excursion to expand symmetrically about the selected "centre voltage".

The drift problem has been tackled by using two highly stabilized anode supplies and a stabilized heater supply for the more critical valves. In general, the short-term stability of output voltage is about 1 mV in normal use. However, as even this value represents excessive drift when using a few microvolts of signal, it is arranged that, on the two lowest ranges of the output control, the variable-level facility is cut out, and the output is taken from a 100-ohm potentiometer, earthed at the bottom end.

Thus, drift is eliminated on these two ranges, at the expense of having to work symmetrically about earth potential. With mains-voltage changes of up to $\pm$ 7%, the drift of the output level is around 5 mV on the four upper ranges. Superimposed on this is a change in the peak-to-peak amplitude of about 0·2%.

Method for the Combined Processing and Power Utilization of Solid Fuels

(*Concluded from page* 63)

granular fuel (breeze), a cyclone type of furnace can be used satisfactorily, as has been established by tests in a special plant. The operational conditions of such a furnace in a combined processing and power utilization plant become especially favourable, as heat release can, in this case, be increased considerably, compared with that normally obtained in this type of furnace.

The developments here envisaged may evolve into additional and more complex schemes, providing substantial fuel economy for the majority of large consumers. Among such schemes is the possible combined processing and power utilization of fuel for the production of pig iron and steel outside blast-furnaces. Moreover, the production of water-gas, pure carbon dioxide, and hydrogen, as well as the combined treatment of solid fuels with a high sulphur content, of residual oils, and of other heavy liquid fuels, is considered.

Similarity Considerations for Rotodynamic Machines

(*Concluded from page* 64)

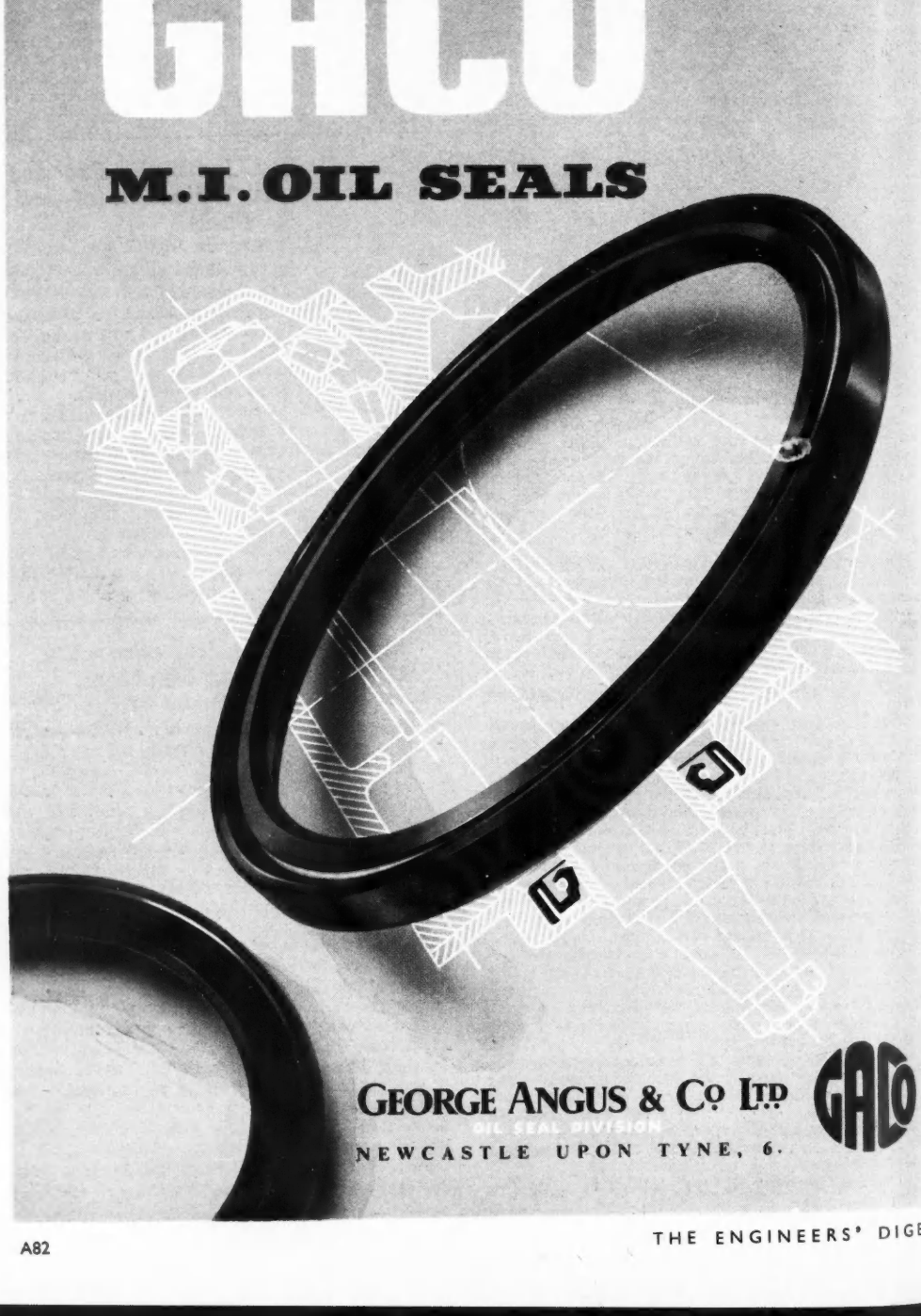
radial-flow machines, an increase in the specific diameter Δ results in an increasing reduction in the exit width of the wheel, and therefore in a further increase in the wetted periphery of the flow channels. For this reason, compressors and blowers are seldom constructed with specific diameters greater than $\Delta = 5$. Water pumps are designed with specific diameters up to $\Delta = 20$.

Free-running propellers, e.g., marine and aircraft propellers, behave in the same way as enclosed axial rotors. A plot of the working points of a group of three-bladed marine propellers shows that free-running propellers in the (specific) velocity/diameter diagram continue the lines followed by enclosed axial rotors in the direction of smaller specific diameters and higher velocity parameters.

The evaluated results from twenty-six water turbines[4,5] of different sizes and types (excluding Pelton wheels) have also been plotted by the author in a σ/Δ diagram. It was found that, by means of non-dimensional expressions for other design parameters, such as hub diameter and rotor width, it is possible to obtain a clear indication of the corresponding relationships and to prepare suitable sets of basic design data from the experience available.

GACO

M.I. OIL SEALS



GEORGE ANGUS & Co LTD
OIL SEAL DIVISION
NEWCASTLE UPON TYNE, 6.

GACO

NEWS OF THE MONTH

PERSONAL

Mr. S. M. Aisenstein, one of the world's foremost valve designers and a pioneer of wireless telegraphy, has retired from his position of general manager of the English Electric Valve Company, Chelmsford, but will be retained as a consultant to the English Electric Group in the field of vacuum physics. He is succeeded by his deputy, **Mr. A. J. Young**, who has been associated with him for many years.

Mr. N. G. Bassett-Smith, sales manager of Dunlop Special Products Compositions Division, has been elected vice-chairman of the Midland centre of the Institute of British Carriage and Automobile Manufacturers.

Mr. J. R. Brinkley has been appointed managing director of Pye Telecommunications Ltd., Cambridge, and an executive director of Pye Ltd.

Mr. D. W. Burnand, B.Sc., A.M.I.E.E., has been appointed sales manager of the Electrical Division of Wakefield-Dick Industrial Oils Ltd., 46 Grosvenor Street, London, W.1.

Mr. B. R. Cant has been appointed general works manager of the National Gas and Oil Engine Co. Ltd., Ashton-under-Lyne. **Mr. S. Cooper** has been appointed to succeed Mr. Cant as works manager of J. & H. McLaren Ltd., Leeds.

Mr. E. B. Christie has been appointed sales manager of Roto-Finish Ltd., 39 Park Street, London, W.1, in succession to **Mr. R. B. Olliver**, who has been elected to the Board with special responsibility for new projects and developments. **Mr. T. S. Gibbons** is sales director.

Mr. H. R. Daddow has been appointed works manager of Simms Motor Units Ltd.

Mr. Elliot D. Digby has been appointed area manager of Delapena & Son Ltd., Zona Works, Cheltenham, for Scotland and Ireland.

Mr. C. M. Flurscheim, B.A., M.I.E.E., Mem.A.I.E.E., who since 1953 has combined the position of assistant chief electrical engineer with that of chief engineer, Switchgear Department, will devote his whole time to the former appointment. **Mr. E. Nicholson, M.B.E., T.D., B.Sc., A.M.I.E.E.**, has been appointed chief engineer, Switchgear Department, Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester 17.

Mr. B. L. Goodlet, O.B.E., M.A., M.I.C.E., M.I.E.E., M.I.Mech.E., has been elected to the Board and has been appointed chief engineer of Brush Electrical Engineering Co. Ltd., Loughborough.

Mr. R. T. Griffiths has been appointed general sales manager (Home) and a director of Hoover (Washing Machines) Ltd., Perivale, Greenford, Middlesex. **Mr. V. C. Mumford** has been appointed general sales manager (Export) and a director of Hoover (Washing Machines) Ltd. **Mr. R. L. Webster** has been appointed chief personnel manager and a director of Hoover (Washing Machines) Ltd. **Mr. A. W. Bunn** has been appointed sales manager and deputy general sales manager (Home), **Mr. P. M. J. Evans**, export sales manager and deputy general sales manager (Export), and **Mr. G. S. McNamara**, export sales promotion manager. **Mr. G. J. Hemmings** has been appointed general sales manager (Continent) at L'Etablissement Hoover S.A., Brussels, for all Continental business except in France.

Mr. L. H. S. Halling, sales manager of A.P.V.-Paramount Ltd., Manor Royal, Crawley, Sussex, has been elected to the Board of the company.

Emeritus Professor Sir Thomas H. Havelock, M.A., D.Sc., F.R.S., has been awarded by the Institution of Naval Architects the William Froude Medal for his outstanding contribution to naval architecture and shipbuilding.

Mr. W. P. Howard has been appointed publicity manager of Ferodo Ltd., Chapel-en-le-Frith, Stockport. He was formerly a member of the publicity organization of The General Electric Co. Ltd.

Mr. W. Hutter has joined Auto Diesels Ltd., as home sales manager for the STAD industrial engines.

Mr. Henry Knewler, A.M.I.C.E., F.R.Ae.S., technical director of Saunders-Roe Ltd., has retired. He will act as an independent aeronautical consultant from his home address at Windward, Fishbourne, Isle of Wight.

The Hon. Michael Layton, A.M.I.Mech.E., has been appointed sales controller of The Steel Company of Wales Ltd., Abbey Works, Port Talbot, who will establish their own inedpendent sales organization.

Mr. J. D. Markland, M.I.E.E., A.I.Mech.E., has been appointed homes sales manager of Hotpoint Electric Appliance Co. Ltd., Peterborough.

Mr. J. B. Mavor, chairman of Mavor & Coulson Ltd., Bridgeton, Glasgow, has retired after thirty-five years of service on the Board. **Mr. J. D. Lloyd**, sales director, has joined **Mr. David Jackson** as joint managing director. **Mr. R. J. Hird**, director and chief engineer, has been appointed works director.

Mr. H. Melhuish has been appointed assistant managing director and head of the Powerplant Division of the Superheater Co. Ltd. **Mr. L. C. Southcott** has been appointed personal assistant to the managing director, **Mr. E. A. Robinson**, and retains his position as director and chief engineer of the company.

Mr. S. W. Mills, F.C.W.A., manager of the Coilwinding Division, and **Mr. E. H. Twaits**, manager of the Components Division, have been appointed executive directors of The Plessey Co. Ltd., Ilford, Essex.

Mr. Arthur R. Mitchell and **Mr. Evan R. Cameron, B.Sc.**, have been elected to the Board of Yarrow & Co. Ltd., Glasgow.

Mr. J. J. Molins, chief designer, has been appointed an executive director of Microcell Ltd., 56 Kingsway, London, W.C.2.

Mr. C. B. Morton, D.S.O., M.B.E., D.F.C., has been appointed general manager of Spiro-Gills Ltd., Pulborough, Sussex.

Mr. W. L. Munday has been appointed engineer-in-charge of the Aeronautical Division of Marconi's Wireless Telegraph Co. Ltd., Croydon, in succession to **Mr. H. T. Sayer**, who has retired after forty years of service with the company.

Mr. D. P. C. Neave, vice-chairman of Consolidated Zinc Corporation Ltd., has been elected chairman of the Zinc Development Association, 34 Berkeley Square, London, W.1, in succession to **Mr. William Mure**, managing director of British Metal Corporation Ltd., who will continue to serve, however, as a member of the Council.

Mr. W. B. C. Perrycoste and **Mr. J. Salter** have been appointed joint general production managers of British Aluminium Co. Ltd., Norfolk House, St. James's Square, London, S.W.1, to succeed **Mr. S. F. Derbyshire**, who has retired, but will continue in consultative capacity. **Mr. P. T. Ensor** has been appointed general manager, and **Mr. A. R. Wylie**, works manager designate of the Canadian British Aluminium Co. Ltd., Baie Comeau, Canada.

Mr. K. H. Platt, M.B.E., B.Sc., M.I.Mech.E., has been appointed deputy secretary of the Institution of Mechanical Engineers.

Lord Strathalmond of Pumpherston, C.B.E., LL.D., is relinquishing his position as chairman of British Petroleum Co. Ltd. on 31st March, after thirty-three years of service on the Board. **Mr. B. R. Jackson**, deputy chairman, will be elected chairman and **Mr. N. A. Gass, C.B.E. M.C.**, deputy chairman, as from 1st April. **The Hon. M. R. Bridgeman, C.B.E.**, will be elected to the Board.

Mr. Ronald S. Punt, B.Sc.(Eng.), A.M.I.Mech.E., A.M.I.Mar.E., has been appointed chief engineer and designer to H. Widdop & Co. Ltd., diesel engine manufacturers, Keighley, Yorkshire.

Mr. B. Smith, A.M.I.Prod.E., and **Mr. C. E. Middlemiss, B.Com., M.S.M.A.**, have been elected to the Board of Clarkson (Engineers) Ltd., Nuneaton.

Mr. Frank Spencer has relinquished his position as managing director of Hotpoint Electric Appliance Co. Ltd., Peterborough, but remains on the Board in an advisory capacity. He will be devoting more time to the development of Opperman Gears Ltd., Newbury, whose director he has been for many years.

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This new acoustical instrument ends guesswork in locating and detecting faults. The AIRSONIC is acutely sensitive to changes in the characteristic rhythms or sounds of mechanical and electrical equipment; of pipelines above or below ground; of metals, plastics and other materials. Whether known to exist or still unsuspected, the AIRSONIC will pin-point the exact trouble spot—tracing unwanted noises, revealing leakages, discovering unsound joints, detecting excessive wear or metal fatigue.
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The AIRSONIC tunes in to trouble, tunes out unwanted frequencies. Saves time and labour in plant maintenance, avoids costly breakdowns. AIRSONIC, the infallible fault-finder, is compact, non-electric—and quite inexpensive.
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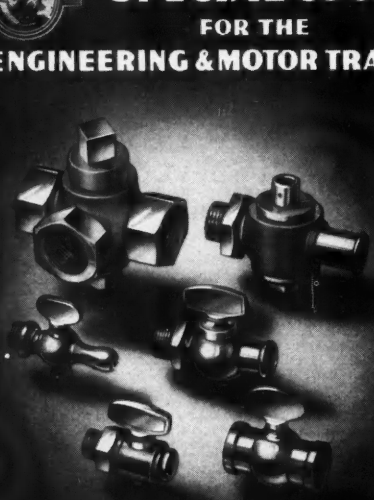

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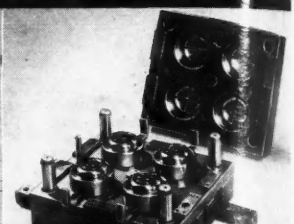

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Established 18

Mr. A. **Starr** has been appointed assistant export manager of Tecalemit Ltd., Brentford, Middlesex. He is responsible to the export manager, **Mr. B. D. Waugh.**

Mr. A. L. Sutherland and **Mr. H. C. White** have been elected to the Board of Philips Electrical Co. Ltd., Century House, Shaftesbury Avenue, London, W.C.2.

Mr. P. S. Walkins, D.F.C., A.L.A., has been appointed librarian and information officer in charge of the Owen Organization library and information service, which is part of the Research and Development Department, at Darlaston.

Mr. E. A. Watson, O.B.E., D.Sc., M.I.Mech.E., has been awarded the 1955 James Clayton Prize by the Council of the Institution of Mechanical Engineers for his notable work in automobile engineering, and for his outstanding contributions in the last fifteen years to the progress of the aircraft gas turbine, particularly in the fields of combustion and fuel control which were the subjects of his James Clayton Lecture in December, 1955.

Mr. C. L. G. Worn, B.Sc.(Eng.), A.M.I.Mech.E., chief gas turbine engineer of Brush Electrical Engineering Co. Ltd., Loughborough, since 1952, has been appointed chief engineer of the company's Turbine Division. He succeeds **Mr. R. C. McLeod**, who has relinquished his executive responsibilities in order to devote his entire time to technical design. **Mr. L. A. Benn, A.M.I.Mech.E., A.M.I.E.E.** has been promoted to chief engineer, Heavy Electrical Plant Department. **Mr. L. E. Robinson**, chief designer of the Brush Ljungstrom radial flow steam turbine, will continue in that capacity. **Mr. J. R. Hutchings** has been appointed engineer in charge of spares and repairs.

Mr. C. E. Wragg, a director of Kayser, Ellison & Co. Ltd., Carlisle Street Works, Sheffield 4, has been appointed to take responsibility for home sales.

MR. E. S. BYNG

We regret to announce the death on 13th January of Mr. Edward Stanley Byng, vice-chairman of Standard Telephones and Cables Ltd.

Mr. Byng received his technical education at Derby School and University College, Sheffield. He joined the Western Electric Company, now Standard Telephones and Cables Ltd., in 1913, was appointed managing director in 1938 and was elected vice-chairman in 1933.

He was a member of the Institution of Electrical Engineers, of which he had been Honorary Treasurer, Fellow of the American Institute of Electrical Engineers and a past chairman of the Telephone Development Association.

Mr. Byng was a member of the Ministry of Education's Central Advisory Council for Education, and he had long been known as an advocate of the greater education of the professional engineer and had urged that the engineer should equip himself as an administrator. He pioneered matters involving management, control of policy, handling of personnel and other functions which had no place in the curriculum of technical instruction, and he was fortunate to live long enough to see much of his work bearing fruit.

SIR FELIX J. C. POLE

We regret to announce the death on 15th January of Sir Felix J. C. Pole who, until August, 1954, was chairman of the British Thomson-Houston Company.

Sir Felix was born on 1st February, 1877, at Great Bedwyn, Wiltshire. He was educated at Ramsbury, and on leaving school joined the Great Western Railway, rising to the position of general manager. This position he held from 1921 to 1929 when he was appointed chairman of the A.E.I. group of companies. In 1946 he succeeded the late Mr. W. C. Lusk as chairman of the British Thomson-Houston Company, remaining in office until 1954 when he relinquished his seat on the Board.

Sir Felix was well known throughout the manufacturing organization in the A.E.I. group for his humanitarian principles, precept and practice. To him "man" came before "machinery". Wherever he went he insisted on a personal introduction to all who came within his orbit. He showed the liveliest interest in the welfare of each individual—by no means restricted to the person's professional or work-a-day capacity but embracing pastimes and leisure pursuits.

He was loved for his personal qualities as much as respected for his business acumen and strict integrity, from shop floor to top management.

BRITISH ELECTRICAL POWER CONVENTION

"Electricity and Transport" will be the theme of the eighth British Electrical Power Convention which is to be held at Torquay under the presidency of Sir John Dalton, A.M.I.E.E., F.C.I.S., chairman, W. T. Henley's Telegraph Works Co. Ltd. The Electrical Convention Exhibition will occupy 30,000 sq ft of the Torre Abbey Meadows and will be officially opened by Sir John Dalton on the evening of Wednesday, 23rd May.

The Convention will be opened on Thursday, 24th May, by a Civic welcome from the Mayor of Torquay, followed by the presidential address.

On the morning of Friday, 25th May, the following papers will be delivered :—

"Electricity in Rail Transportation" by Mr. S. B. Warder, M.I.Mech.E., M.I.E.E., M.I.Loco.E., chief electrical engineer, British Transport Commission, British Railways Division. "Electricity Supply and the Railway Load" by Messrs. F. J. Lane, O.B.E., deputy chief engineer (Transmission), Central Electricity Authority, and W. B. Noddings, M.Eng., M.I.E.E., chief commercial officer, Central Electricity Authority.

The following three papers will be given on Friday afternoon, "The Electric Locomotive and the Diesel Electric Locomotive" by Mr. C. M. Cock, M.I.Mech.E., M.I.E.E., A.M.I.E.Aust., M.I.Loco.E., general manager, Traction Department, English Electric Co. Ltd., London. "Electric Multiple Unit Trains and Equipment" by Mr. F. A. Manley, manager, Traction Department, General Electric Co. Ltd., London. "Electric Signalling Systems for Rail and Road Transport" by Mr. D. C. Shipp, B.Sc., M.I.E.E., M.I.R.S.E., assistant manager, Signalling Division, Westinghouse Brake and Signal Co. Ltd., London.

Saturday morning's session comprises three papers on "Electrification of Railways in the Commonwealth" by Messrs. E. L. E. Wheatcroft, M.A., M.I.Mech.E., M.I.E.E., and H. H. C. Barton, B.A., M.I.Mech.E., M.I.E.E., M.I.Loco.E., M.Inst.T., of Merz and McLellan. "Overhead Lines for Rail and Road Electrification Schemes" by Messrs. C. F. Allen, A.M.I.E.E., chief traction engineer, and C. P. Goodman, M.I.E.E., British Insulated Callender's Construction Co. Ltd., Kirkby, Lancs. "Sub-Station Equipment for Rail and Road Systems" by Messrs. G. S. Causon, A.M.I.E.E., director and joint manager, Hackbridge and Hewittic Electric Co. Ltd., and F. G. Stevens, A.M.I.E.E., rectifier sales manager, Hackbridge and Hewittic Electric Co. Ltd., Walton-on-Thames, Surrey.

The Convention golf competitions take place on Saturday afternoon.

When the business sessions are resumed **in the Town Hall** on Monday, 28th May, there will be an interlude in the transport theme, when a paper, with demonstrations, on "The Electric House" will be presented on behalf of The British Electrical Development Association by Mr. D. Bellamy, O.B.E., D.L., F.A.C.C.A., F.C.W.A., Companion I.E.E., F.R.Econ.S., F.S.S., Vice-chairman of the British Electrical Development Association and chairman, Yorkshire Electricity Board.

This paper—the only one dealing with the domestic applications of electricity—is to be supported by the erection, near the Exhibition, of a three-bedroom bungalow, containing all the most up-to-date electrical equipment and appliances. Between the bungalow and the main exhibition will be a large hall in which the South-western Electricity Board will present a complete display of the various models of the appliances included in the bungalow.

Again in **the Town Hall** on Monday afternoon, transport will be the subject of two papers :—

"Electric Trolley Buses and Trams" by Mr. J. H. Cansdale, M.I.E.E., M.I.Loco.E., deputy manager, Contracts, Traction Department, The British Thomson-Houston Co. Ltd., Rugby. "Battery Electric Vehicles" by Messrs. H. W. Heyman, B.Sc., M.I.E.E., Smith's Delivery Vehicles Ltd., Gateshead-on-Tyne, Peter Rochs, Austin Crompton Parkinson Electric Vehicles Ltd., London, and H. R. Simpson, A.M.I.Mech.E., T.H. Lewis Ltd., Watford. This paper will be presented on behalf of the Electric Vehicle Association of

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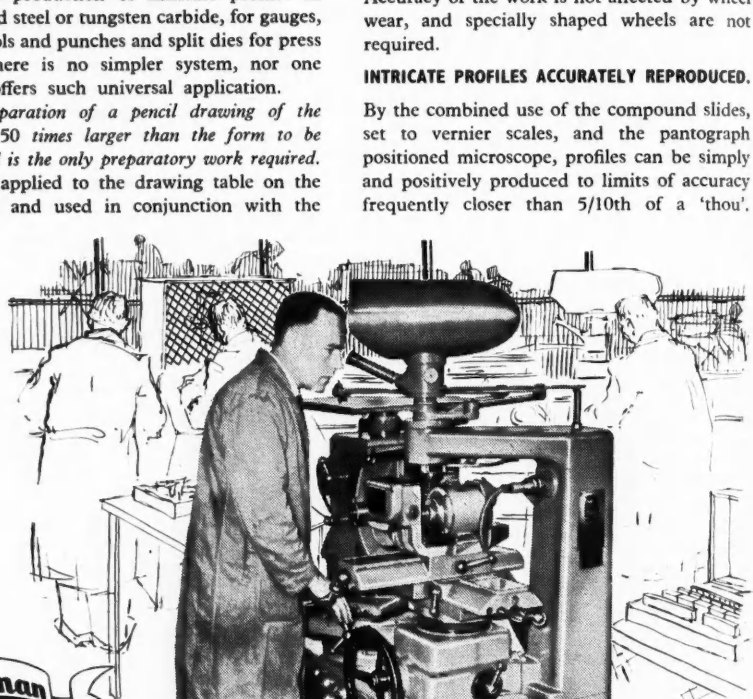

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Great Britain Ltd., by Mr. V. W. Dale, Companion I.E.E., vice-chairman of the Association.

On Monday night the Convention Dinner will be held in the Palace Hotel, and the Annual Convention Dance, in the Town Hall.

The concluding session takes place in the Pavilion on the morning of Tuesday, 29th May, with the Electrical Forum, in which a team of experts answer questions on electrical matters. This is followed by the annual general meeting at which new officials are elected and the venue of the 1957 Convention decided.

TECHNICAL EDUCATION IN RUSSIA

In an effort to determine the accuracy of current claims that the Soviet Union is producing far more trained scientists and engineers than the United States, the current issue of the **R.P.I. Engineer**, a technical magazine published by students at Rensselaer Polytechnic Institute, carries an article, " Technical Education in Russia ".

Submitted at the magazine's request by the Embassy of the U.S.S.R. in Washington, D.C., the article, if accurate, substantiates recent warnings by leading United States authorities that Russia is making an all-out attempt to gain ground in the race for world leadership in science and engineering. One U.S. authority, Lewis Strauss, chairman of the Atomic Energy Commission, recently warned that in the decade 1950–60 the Russians would produce 1,200,000 scientists and engineers compared to 900,000 in the United States.

According to the article submitted by the Russian Embassy, students in the Soviet receive far more classroom instruction and on-the-job training while in college than their counterparts in the United States. In the Soviet, the article continued, students may study for five years at technical institutes or five and one-half years at the polytechnic institutes. The course taken by the Russian student provides for study in theory, laboratory work and industrial training in factories and plants.

A comparable programme in the United States is the work-study programme in which the students spend certain periods working in industry during the four-year college career. A very small percentage of United States engineering students are enrolled in this type of programme.

Citing as an example the training of specialists in machine building, metal-cutting machines and tools, " one of the basic specialities in the Soviet Union ", the article stated that the curriculum provides for a five-year course with 4886 obligatory hours, including lectures, laboratory work, practical studies and course papers.

In comparison, the broader and more fundamental engineering courses in the U.S.A. have nearly 20% less classroom hours, including lectures and laboratories.

Almost no time is spent in the study of liberal arts and humanities in Russia. The only subjects taken by the Russian student which can be classed as non-technical are one foreign language and the social sciences which are described in the article as, " the fundamentals of Marxism-Leninism, Political Economy and the Organization of the Machine Building Industry ". Striving to turn out a well-grounded individual, Rensselaer schedules approximately 20% of a student's time in the social sciences and humanities.

In addition to the regular technological and polytechnic institutes, the article states that Russia has recently opened 250 specialized technical schools with one- and two-year courses covering all branches of industry and agriculture. These schools train skilled workers and junior technical personnel in trades requiring a general educational level above the average. The students of such schools are supported at the expense of the State.

The Russians also have a huge correspondence school system with 580,000 students. These schools have trained thousands of engineers and other specialists, the article said.

According to figures cited in the article attendance in secondary schools in Russia increased by 4,000,000 between 1950 and 1954. In 1954 the secondary schools graduated 880,000 students and a total of 1,200,000 is expected to graduate by the end of 1955. These reported increases will make even more students available for technical training.

BUSINESS NOTES

Hunt & Mitton Ltd., Oozells Street North, Birmingham 1, announce that they are sole licensees and manufacturers for Europe and the British Commonwealth (excluding Canada) for Cycle Controllers, developed by the Sinclair-Collins Valve Co., 454 Morgan Avenue, Akron, Ohio, U.S.A. These cycle controllers meet the requirements for a timer to control the varied and complex cycles in automatically controlled hydraulic presses. Easily operated, they do not require calculations, charts or trained technicians to make a set-up.

For 300 and 3000 psi hydraulic pressure a 4-way valve has been developed for operating a double-acting hydraulic cylinder. " O " rings are used in these valves to prevent leakage and reduce wear.

Standard Sinclair-Collins products include a two-pressure hydraulic valve and two- and three-way valves for 4000 and 6000 psi hydraulic pressure.

Borax Consolidated Ltd. and **A. Boake, Roberts & Co. Ltd.** announce their association in the production and marketing of organic boron compounds. Enquiries should be addressed to Borax Consolidated Ltd., Borax House, Carlisle Place, London, S.W.1.

Hall & McLelland Ltd. have moved to 351 Brixton Road, London, S.W.9. Tel. Nos. BRIxton 4068 and 4277.

The British Thomson-Houston Co. Ltd. announce that their Liverpool district office has moved to 18 Hepworth Chambers, Church Street, Liverpool 1. Tel. No. Royal 4391. The BTH Lamp and Lighting Department remains at 27/29 Stanley Street. Tel. No. Central 4171.

Keelavite Rotary Pumps & Motors Ltd., Allesley, Coventry, announce that their telephone number has been changed to Meriden 441.

The 40th Swiss Industries Fair will be held in Basel from 14th to 24th April to provide a truly representative display of Swiss industrial production. A particularly comprehensive display of Swiss precision products, alongside those of the electrical industry and general engineering, can be expected. Technicians and buyers from all over the world are already making their plans for visiting this great annual industrial show.

The Dunlop Rubber Co. Ltd. have formed a new division which has now taken over from the Company's general rubber goods division responsibility for the manufacture and sale of hose in the United Kingdom. Mr. P. A. Bridge, sales manager of the general rubber goods division's mechanical group, has been appointed manager of the new hose division, and in the meantime will continue to operate from the Company's works at Cambridge Street, Manchester. The sale of high pressure hose by the Dunlop Aviation Division is not affected.

Costain-John Brown Limited have been appointed by the Government of India to advise them regarding the types of heavy water plant which they should install to meet the forward commitments of their atomic energy programme. Their immediate needs may well be met by the installation of plants associated with nitrogen fertilizer factories.

The heavy water plant constitutes a substantial portion of the Indian Government's projects running into many millions of pounds.

The integration of heavy water production with the manufacture of fertilizers, means that the heavy water may be produced for considerably less cost than other methods such as that proposed for the New Zealand Wairakei scheme where it was to be produced in conjunction with the generation of electric power.

The Mond Nickel Fellowships Committee now invites applications for five Fellowships of an approximate value of £900 to £1200 each for 1956. Fellowships will be awarded to selected candidates of British nationality with degree or equivalent qualifications to enable them to obtain wider experience and additional training in industrial establishments, at home or abroad, to make them more suitable for future employment in senior technical and administrative positions in British metallurgical industries. Each Fellowship will cover one full working year. Applicants will be required to state details of the programme they wish to carry out. Particulars and forms of application are available from The Secretary, Mond Nickel Fellowships Committee, 4 Grosvenor Gardens, London, S.W.1. Completed application forms are required by 1st June, 1956.

C. E. Johansson Ltd., Southfields Road, Dunstable, Beds., announce the availability on loan of a 16-mm film with sound track on Mikrokator comparators, surface finish indicators, micro hardness testers, extensometers and dynamometers, manufactured by A/B C. E. Johansson, Eskilstuna, Sweden.

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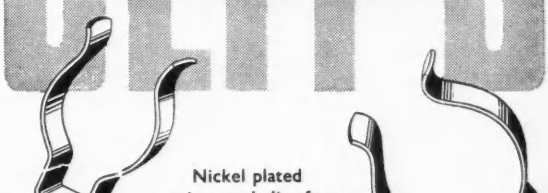

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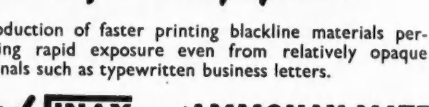

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BRI311-AH

"The **Functions and Education of Welding Engineers**" will be the theme of a Conference organized by the Institute of Welding at Ashorne Hill from 16th to 18th September next. Some twenty-two papers have been promised and will be discussed in four sessions. The first group will deal with the "Functions of the Welding Engineer in Industry", the second with "The Present Place of Welding in Advanced Technical Education in this Country", and the third with "The Practice of other Countries", including the United States, France and Germany. In the last session a number of suggestions for the improvement of the facilities for the education of welding engineers will be described and discussed.

It is expected that the Conference will attract, beside welding engineers, those concerned with technical management in the engineering industry, and teachers of engineering subjects from the universities and technical colleges.

Sheepbridge Equipment Ltd. announce that they are to manufacture the Schaffer Poidometer in England.

The Schaffer Poidometer is an accurate feeder-weigher used in mining, milling, smelting, refining and concentrating industries. It handles all crushed, granulated and pulverized matter. It is extensively used in the United States to weigh and feed coal to furnaces and driers and at the same time keep an accurate fuel consumption record. In mechanical plants, poidometers handle such materials as bauxite, phosphate rock, soda ash, soap powder materials, alum and lime, making possible improved quality by accurate proportioning by weight.

Clay products, feed fertilizers, oil refining, metalwork and water purification industries all offer numerous applications for the Schaffer Poidometer.

Birlec Limited announce that they are shortly to begin the construction of a second giant arc melting furnace at Stocksbridge Sheffield, works of Samuel Fox & Co. The new furnace has been ordered in connection with Samuel Fox's current development schemes, which include a new blooming mill and billet finishing mill, as well as a new combination bar and continuous rod rolling mill. It is to be larger than the existing furnace which is already the biggest of its kind in the United Kingdom and one of the largest in Europe. Equipped with a swing roof and 20-in. diameter electrodes, the new furnace is to have a shell diameter of 20 ft, a transformer capacity of 20,000 kVA, and will be provided with on-load tap change gear.

The two furnaces, which will be housed within the same building, will have a joint pouring capacity of approximately 150 tons and when operating simultaneously will consume sufficient power to supply the domestic requirements of a town with a population of 100,000.

Vitaloid Products (Manchester) Ltd., makers of "Vitaseal" and "Vitashield" gummed tapes, have formed a new division to market an advanced type of Polythene film ideal for the packing and protection of goods.

The name of this new material is "Flexothene". It has a guaranteed consistent gauge, is practically non-static and has permanent ink adhesion for excellent colour printing. It is obtainable plain or printed as film, layflat tubing, bags and as laminations with a variety of other packaging materials.

Illustrated folder giving full details may be obtained together with samples of all types from the Flexothene Division of Vitaloid Products (Manchester) Ltd., 11 Duke of York Street, St. James's, London, S.W.1.

F. Perkins (Canada) Ltd. have moved into a newly erected building in Wingold Avenue, Toronto, Ontario, Canada. Provision has been made to accommodate trucks and trailers used in development work on automotive diesel engines and machines for prototype installation work.

CONTRACTS

The General Electric Co. Ltd. has received an order from Simon-Carves Ltd., for two 8000 kW double pass-out condensing turbo-alternators. Installation of these sets in the carbonization plant will form part of the modernization which the National Coal Board is effecting at Cwm Colliery in South Wales.

Inlet steam conditions of this single-cylinder turbine are 400 psig, 800°F t.t., and the exhaust is into a vacuum of 28·0 in Hg. The pass-out steam pressures are 130 psig and 25 psig. The maximum quantities of steam which may be passed to process are 27,480 lb/hr at the first pass-out stage, and 25,590 lb/hr at the second pass-out stage.

Each of the 3000 rpm alternators will have an output of 8000 kW at 11 kV, 0·8 power factor, and will draw its field supply from a main exciter nominally rated at 55 kW. The armature of this exciter and that of the associated pilot exciter will be mounted on a common shaft which will be flexibly coupled to the alternator rotor.

The main alternator ventilation system will comprise a closed air circuit including a Heenan & Froude air cooler capable of cooling 20,000 cu ft of air per min to a maximum temperature of 95°F. The cooling air for the totally enclosed sliprings will be drawn from the exciter ventilation system.

W. G. Bagnall Ltd. of Stafford have received an order from the Mysore Iron and Steel Company of India for a steam locomotive. It is a 2–8–2 tender engine with cylinders of 12½ in. × 18 in., the rail gauge being 2 ft.

Rustenburg Platinum Mines of South Africa have also placed an order for two diesel mechanical locomotives powered by Gardner 8L3 engines developing 200 hp. The wheel arrangement is 0–6–0 and the locomotives are for use on 2 ft gauge track.

From Railway Mine and Plantation Equipment Ltd. Bagnalls have received an order for two 0–8–0 locomotives powered by National M4AA6 engines developing 230 hp. These are designed for a 3 ft 3⅜ in. track and will weigh 32 tons in working order.

A Fir·less (steam storage) 0–4–0 shunting locomotive has been ordered by English Clays Lovering Pochin & Co. Ltd. of St. Austell, Cornwall. This will have cylinders 18½ in. dia × 18 in. stroke, the reservoir pressure is 250 psi and the working pressure 80 psi.

The North Thames Gas Board is spending over £500,000 on a tower purifier to be installed at the Beckton Gas Works. It will treat 30,000,000 cu ft of gas daily.

Henry Balfour & Co. Ltd., Leven, Fife, will erect this plant which should be completed in two years.

The Beckton tower purifier will be 215 ft long, 76 ft high and 100 ft wide, and will be constructed from 4000 tons of welded steel.

The plant, which is mechanically operated, consists of a huge welded steel container, sub-divided into 15 tower boxes, each containing 16 trays, each tray holding 33 tons of oxide, whose purpose is to remove sulphur impurities from the entering gas. (The total amount of oxide in circuit is approximately 8000 tons.)

Gas enters each box through the large connecting mains, passes down through the oxide and is purified. It is then collected off and goes on to the remainder of the ancillary plant.

When the spent oxide in one of the boxes needs to be changed, this is performed automatically by a mechanical device which tips it from the trays, later re-charging them with fresh oxide. During this operation, the gas normally passing through that tower box is switched to a spare tower box.

Heenan & Froude Ltd., Worcester, have received an order from Tampella Oy, for a Mark VII Heenan Dynamatic dynamometer with a maximum capacity of 2100 bhp. This machine will be used to test complete propulsion units of diesel-hydraulic locomotives.

In September, 1955, Tampella received a contract to build 16 of these units (800 bhp) to be made under licence from M.A.N. of Augsburg, complete with torque converters made under Swedish licence.

The effect of a hydraulic torque converter is to give substantially the normal engine torque when running at high speeds, but a greatly increased torque when running at low speeds, to such an extent in fact that the standstill torque (available for starting the locomotive from rest) may actually exceed the adhesion factor between locomotive and rails.

This made it quite difficult to offer a dynamometer which at one and the same time would cater for normal torque at high speeds and a greatly increased torque at low speeds. With the exceptionally wide range between maximum and minimum power which is available on a Heenan Dynamatic dynamometer, it is possible to meet the requirements, including the measurement of standstill torques. The latter requirement is met by a simple device which positively locks the dynamometer shaft to the dynamometer casing, so that although the engine may be running at full throttle, the output shaft is stalled.

Apart from testing the M.A.N. engines themselves, a main object is to find the final output from the torque converter so as to check the overall efficiency of the whole propulsive unit, and enable calculations to be made of the net tractive effort which will be available at the locomotive wheels.

Metropolitan-Vickers Electrical Co. Ltd., through its associated company Associated Electrical Industries (India) Ltd., has obtained an order from the Punjab Government covering five water-turbine-driven a.c. generators for the first stage of the Bhakra Dam project on the Sutlej River in Northern India. Each generator will have an output of 100,000 kVA at 166·7 rpm, the voltage being 11 kV three-phase 50 c/s and the power factor 0·9. They are for driving by Francis-type turbines of 125,000 hp each.

The generators will be of the vertical-shaft type with a thrust bearing above the rotor and two guide bearings, one above and one below. Among the ancillary equipment included in the order are five Metropolitan-Vickers type VTSR automatic voltage regulators, which are of the quick-response magnetic amplifier type.

The order is one of the largest ever received by a British manufacturer for this type of equipment, being valued at over £1 million, and the project, when completed, is expected to be the largest hydro-electric scheme in Asia.

Classified Advertisements

The rate for all classified advertisements is 6d. per word; in bold print 9d. per word; minimum order 6s. Box-number advertisements 1s. extra. Instructions, together with remittance, must be received not later than the 3rd of each month for advertisements to appear in the same month's issue.

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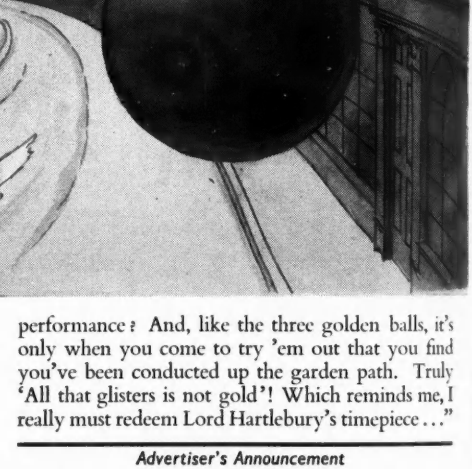
THREE GREAT golden balls glistened in the moonlight. "Zounds!" cried the First Robber — "there's as pretty a sight as ever I did see, all set out werry neat and orderly, and all a-ready for the taking of by two enterprising gents with an eye to business. Do you give me a leg, Skipper, and I'll part 'em from their moorings werry brisklike— afore ye can say Jack Ketch!"

"Tch!" murmured his companion, a man of sharper intellect and wider experience than honest Jeremy —"such simple faith is sadly misplaced, old friend. These globes are neither gold nor other precious metal, being wrought — probably in Birmingham — of brass. Hollow at that —" he added testily, rapping one of them with his cane. It gave out a dull, lack-lustre note.

Jeremy frowned. "Werry misleading and unethical," he muttered, "It's them sort of things from what man's ingratitood springs." He paused, pleasingly fuddled by his little rhyme.

"Speaking of springs," said the Captain darkly, and sounding suspiciously like an advertisement, "there's *another* bone of contention in this imperfect world. Did you know that the cheapest of springs may look every bit as good as the finest quality spring, specially designed and made for ultra-high performance? And, like the three golden balls, it's only when you come to try 'em out that you find you've been conducted up the garden path. Truly 'All that glisters is not gold'! Which reminds me, I really must redeem Lord Hartlebury's timepiece..."

Advertiser's Announcement



M-W. 421

BOOKS RECEIVED

Tool and Cutter Grinding. By Robert S. Connell. 160 pp., 182 illustrations. Publishers : The Machinery Publishing Co. Ltd., National House, West Street, Brighton 1. Price : 17/6.

Recently added to *Machinery's* Standard Reference Series, this excellently produced and illustrated publication is a comprehensive text-book dealing with toolroom grinding. It describes equipment and special machines for tool and cutter grinding, and gives detailed instructions for dealing with turning, planing, shaping, and slotting tools, twist drills, milling cutters, thread-cutting tools, broaches, and gear-cutting tools.

Whilst the more experienced will, no doubt, readily recognize many of the set-ups and methods illustrated and discussed in this useful volume, those with less experience will certainly derive considerable assistance in the performance of operations with which they are not so familiar.

Flood Estimation and Control. 3rd Edition, 1955. By B. D. Richards, B.Sc., A.C.G.I., M.I.C.E. 200 pp., 49 illustrations. Publishers : Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price : 35/-.

Floods undoubtedly follow certain natural laws, but the number and complexity of the factors involved and the interplay between them make precise estimation impossible, so that the subject of flood prediction has long been one of the problems of civil engineering. One of the main purposes of this book, then, is to analyse in detail the principal factors affecting flood discharge and to assess the relative importance of these factors and the effects of their interconnection.

This new and revised edition incorporates certain additions of practical value. Thus, for instance, a section, reviewing the disastrous flood at Lynmouth, is included. Other new features include a more complete discussion of the " unit-hydrograph " method of flood estimation, and the adaptation of the author's flood-estimation methods to the special case of a reservoir of large area in proportion to the catchment. In addition, a method of constructing the hydrograph of a flood produced by a moving storm is developed, while the application of the author's theory to large catchments with a very long period of concentration is further considered with special reference to the coefficient of rainfall. The author's approximate method of calculating the flood absorption effect of a reservoir has also been set out more fully.

The flood problem remains of the greatest importance to civil engineers who are called upon to design reservoirs, flood-water channels, roads, and other projects, and there can be no doubt that this book will render them specific aid in their work.

Turboblowers. By A. J. Stepanoff, Ph.D. 386 pp., 222 illustrations Publishers : John Wiley & Sons, Inc., New York, and Chapman & Hall Ltd., 37 Essex Street, London, W.C.2. Price : 64/-.

In the last fifteen years, unprecedented developments have taken place in the field of application of turbomachinery for the compression of gases and vapours. This book deals with the hydrodynamic and thermodynamic aspects of turboblower design, outlining new methods of attack on turbomachine problems, and discussing the art of building turbocompressors in the United States and abroad. European designs occupy a prominent part of the book.

In addition to offering a balanced picture of past and current work in the field, the author explores a number of new methods and techniques. He presents a theoretical treatment of the compressor impeller, based on a single pattern of flow, and extends this treatment to similar design procedure for centrifugal and axial-flow impellers. Another chapter stresses the hydrodynamic nature of pressure generation as contrasted with the indirect thermodynamic basis commonly adopted in the past, while another chapter is devoted to water-cooled compressors, in which a design method is offered with detailed numerical examples and complete energy balance.

The axial-flow compressor design method of the author is based on actual fluid deflection and observed pressure and capacity coefficients rather than lift and drag coefficients, which are a part of airfoil theory. The latter is discussed sufficiently to demonstrate its limitations and weaknesses. Also shown are ways by which the performance of fans may be improved with little or no increase in cost.

Mine Rescue Work. By R. McAdam, B.Sc., Ph.D., M.I.Min.E., F.R.S.E., and D. Davidson, M.St.J., M.I.Min.E. 190 pp., 112 illustrations. Publishers: Oliver & Boyd Ltd., Tweeddale Court, Edinburgh 1, and 39a Welbeck Street, London, W.1. Price : 21/-.

This interesting book has been written with the dual purpose of providing an up-to-date text-book for mining students and also a reference work for members of rescue-brigades, men attached to permanent rescue corps, and production officials in the mining industry. The authors, who have had a long and intimate contact with mine rescue work, have covered their subject admirably, approximately half of the book being devoted to the construction and action of the many types of breathing apparatus used in mine rescue work, and the remainder to such subjects as resuscitation, transport of casualties, fire-fighting, mine gases, rescue and fire-fighting plans, and the organization of rescue work. Excellent photographic illustrations and simplified line diagrams are used, whenever applicable.

In addition to a useful index, this book contains a short historical review, from which it is interesting to recall that the first self-contained breathing apparatus of any practical use was produced by Henry Fleuss in 1878. However, although this apparatus was used successfully in at least two colliery disasters, little interest was taken in breathing apparatus in Great Britain until 1902, when Sir Robert H. Davis, of Siebe, Gorman, and Co. Ltd., of London, invited Fleuss to collaborate with him in research work destined to improve the design, the operation, and the efficiency of self-contained breathing apparatus.

LATEST INDUSTRIAL LITERATURE

1. Hydraulic Power Presses. An illustrated 8-page brochure gives details of a standard range of hydraulic power presses with capacities of 12, 20, 35, and 50 tons, each model being a self-contained unit. Outstanding features of these presses include, in addition to their exceptional stroke and daylight, three speeds and three operating pressures in either direction. The return speed is approximately three times that of the corresponding advance speed, while speed selection is obtained instantly at the touch of a switch, which can be operated when the machine is stationary, running light, or under load.

A further valuable feature is a readily accessible tonnage bar on the front of the machine, enabling operating pressure to be preset and at the same time adjusting the relief valve to operate at that pressure. Furthermore, a simple, but effective, design of adjustable stops limits the stroke to that required for a particular operation, thereby eliminating overrun in either direction.

2. Fire Protection by Nuclear Detection. An interesting 10-page brochure describes a system of fire protection by nuclear detection, in which the sensitive element is an ionization chamber wherein the air is rendered conductive by the alpha particles emitted from a small quantity of radium compound with a theoretical life of 1000 years. The entry of smoke or other combustion products into the chamber radically changes the characteristics of the ionized air, caling into action a balanced circuit, the output of which may be used to sound an alarm or to operate automatic fire-extinguishing equipment.

As soon as the system has operated it can immediately be reset. The detectors, suitably sited in the building or built into the equipment to be protected, are connected to a combined control unit and signal panel, which indicates the location at which the alarm originates. Each detector serves to protect about 1000 sq ft of floor area.

3. Screenless Superfine Reduction Mills. In a well produced and illustrated 8-page brochure, descriptions are given of a range of machines for the superfine reduction of many materials, where the production of fine, dry powders smaller than 300 mesh is required, from 1 to 20 microns. The design of the apparatus is such that it is possible to pulverize almost any soft or medium-hard material simply and efficiently to virtually any degree of fineness, without the use of screens or other ancillary equipment at any stage. Thus, the disadvantages attendant on the use of screens are eliminated, inasmuch as screen choking, with loss of production during cleaning, cannot take place, while the fineness of the finished product can be varied by simple air controls, without changing any machine components.

4. Pressure Pipe Assemblies. Details of a wide range of pressure pipe assemblies are contained in a well-produced series of illustrated leaflets, housed in a loose-leaf cover. These assemblies are designed to conduct air, oil, fuels, acid, water, steam, gases, and solvents, and are specially made and adapted for use in aircraft, marine oil-firing, refuelling, fire- and crash-tenders, earth-moving equipment, and for research and experimental purposes.

5. ½-in. Capacity Drilling Machine. A sensitive drilling machine, suitable for continuous heavy-duty production and with a capacity of ½ in., is described in an illustrated pamphlet. Equipped with a flanged fixing casting, in place of the machine base, the unit is available for assembly into multi-stage operation machinery. The machine, which is portable and compact, is also available as a semi- or fully-automatic model, incorporating an automatic air-hydraulic power-feed unit.

6. Industrial Engines. Details are contained in a series of illustrated pamphlets of a range of industrial petrol and diesel engines, with capacities between 948 cc and 2·1 litres. The basic engine can in each case be fitted with a variety of components, so as to make any particular compact power unit for individual requirements, and can be arranged for mobile as well as for stationary applications.

7. Industrial Selenium Rectifier Equipment. An interesting and well-produced 20-page brochure describes and illustrates some of the newer uses of selenium rectifier units in industry, including mobile d.c. power supplies, battery chargers, etching equipment, railway signalling gear, equipment for marine use, cathodic protection, experimental equipment for laboratories, and portable emergency lighting units. The standard designs described can be modified in accordance with particular requirements, where desired.

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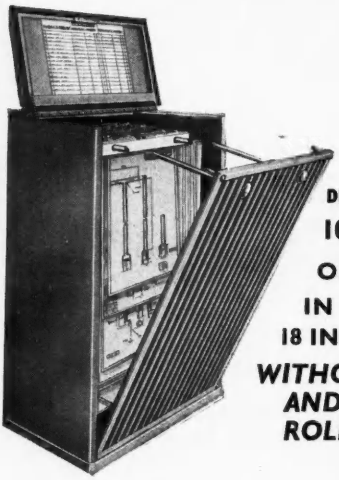

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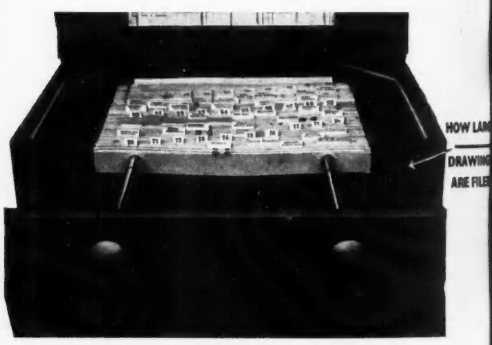

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